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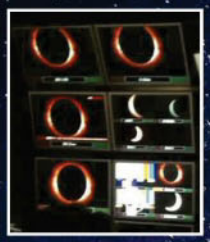

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This month's contributors include...

AMANDA DOYLE
ASTROPHYSICIST

We can't hear the sounds inside stars but, Amanda explains, we can use them to learn a lot about their interiors. *Page 68*

GARY PALMER
IMAGING EXPERT

Gary brings us the first of a two-part image processing project to create a solar mosaic. This month: stacking. *Page 77*

STEVE RICHARDS
EQUIPMENT EXPERT

Steve shows us how to make an azimuth setting circle for a Dobsonian mount in our *How To* project. *Page 74*

GOVERT SCHILLING
ASTRONOMY AUTHOR

Govert tells the story of Scholz's Star, a binary that passed close to our own 70,000 years ago. *Page 58*

Welcome

Looking back at 50 years of Martian endeavour

Earlier this year, NASA enhanced its traffic management system for Mars to ensure that the international fleet of orbiters around it do not get too close to one another. Our satellite surveys of Mars began 50 years ago this month with Mariner 4's flyby, and on page 38 we celebrate the following five decades of scientific insight with a look at 10 of the biggest moments in our robotic exploration of the Red Planet.

There's an insight into an important moment closer to home on page 63, where we hear about the adventures of BBC cameraman Mark Payne-Gill while on assignment for *Stargazing LIVE* this year. For the 20 March total eclipse he had a unique and record-setting challenge: to film the eclipse for live TV broadcast on BBC One from a plane flying into the path of totality. With millions having watched the eclipse live on TV across the globe we know that this feat was achieved, but this glimpse into the preparation involved and the risks overcome casts this endeavour in a whole new light.

The obstacles facing TV production teams are certainly Herculean, but even these are as nothing to the dangers put in the way of planet Earth by the wider cosmos. On page 32 you'll find one of the first visualisations of these risks – apocalyptic events such as asteroid impacts – beautifully illustrated almost 70 years ago by American artist Chelsey Bonestell, one of the founding fathers of space art. Since they were originally published in 1947 our understanding of such doomsday scenarios has grown, so scientist and illustrator Mark Garlick gives an updated commentary on each.

Enjoy the issue!

Chris Bramley Editor

PS Next issue goes on sale 18 June.

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Editorial enquiries
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9.30am to 5.30pm, Mon to Fri
Advertising enquiries
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Subscription email enquiries
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BBC Sky at Night Magazine, Immediate Media Co Bristol Ltd, Tower House, Fairfax Street, Bristol, BS1 3BN

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In the magazine

NEW TO ASTRONOMY?
See *The Guide* on page 72 and our online glossary at www.skyatnightmagazine.com/dictionary

50 YEARS OF MARS EXPLORATION 38

FEATURES

C = on the cover

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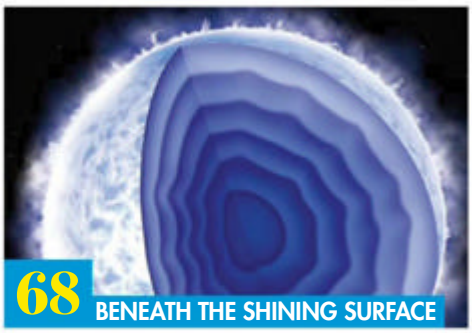

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REGULARS

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EDITORIAL
Editor Chris Bramley
Art Editor Steve Marsh
Production Editor Kev Lochun
News Editor Elizabeth Pearson
Editorial Assistant Iain Todd
Reviews Editor Paul Money

CONTRIBUTORS
Paul Abel, Maggie Aderin-Pocock, Paul F Cockburn, Adam Crute, Jon Culshaw, Lewis Dartnell, Glenn Dawes, Amanda Doyle, Mark Garlick, Will Gater, Olivia Johnson, Pete Lawrence, Chris Lintott, Hazel Muir, Gary Palmer, Mark Payne-Gill, Chris North, Steve Richards, Steve Sayers, Govert Schilling, Giles Sparrow, Paul Sutherland, Stephen Tonkin, Paul Wootton

ADVERTISING SALES
Advertising Managers Steve Grigg (0117 314 8365), Tony Robinson (0117 314 8811)
Inserts Laurence Robertson (00 353 87 690 2208)

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Production Director Sarah Powell
Production Coordinator Stephanie Smith
Ad Services Manager Paul Thornton
Ad Co-ordinator Emily Thorne
Ad Designers Cee Pike, Andrew Hobson
Reprographics Tony Hunt, Chris Sutch

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Director of Licensing and Syndication Tim Hudson
International Partners' Manager Anna Brown

MARKETING
Head of Circulation Rob Brock
Head of Marketing Jacky Perales-Morris
Marketing Executive Ethan Parry
Head of Press and PR Carolyn Wray (0117 314 8812)

PUBLISHING
Publisher Jemima Ransome
Managing Director Andy Marshall

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Director of Editorial Governance Nicholas Brett

Head of UK Publishing Chris Kerwin
UK Publishing Coordinator Eva Abramik
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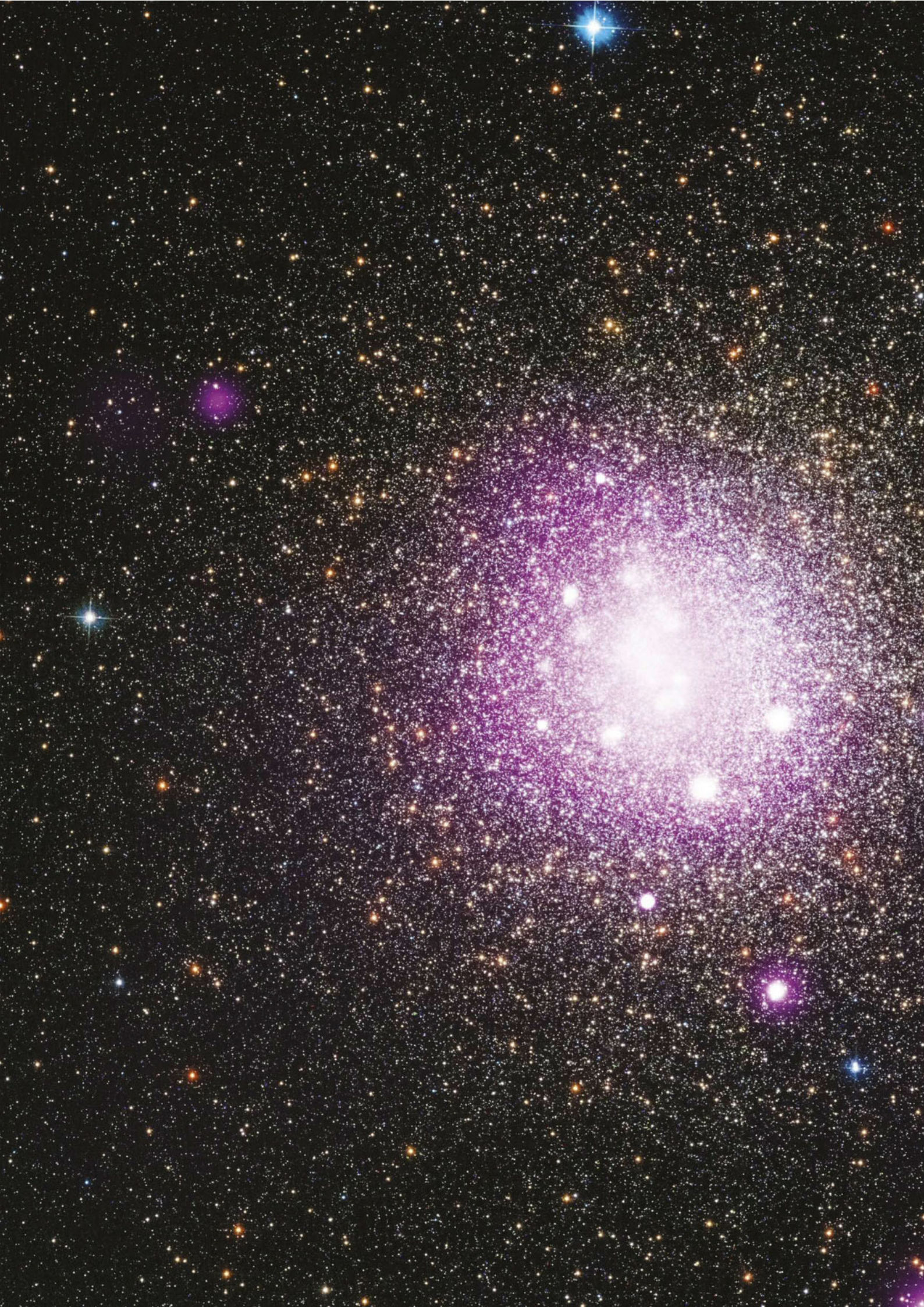
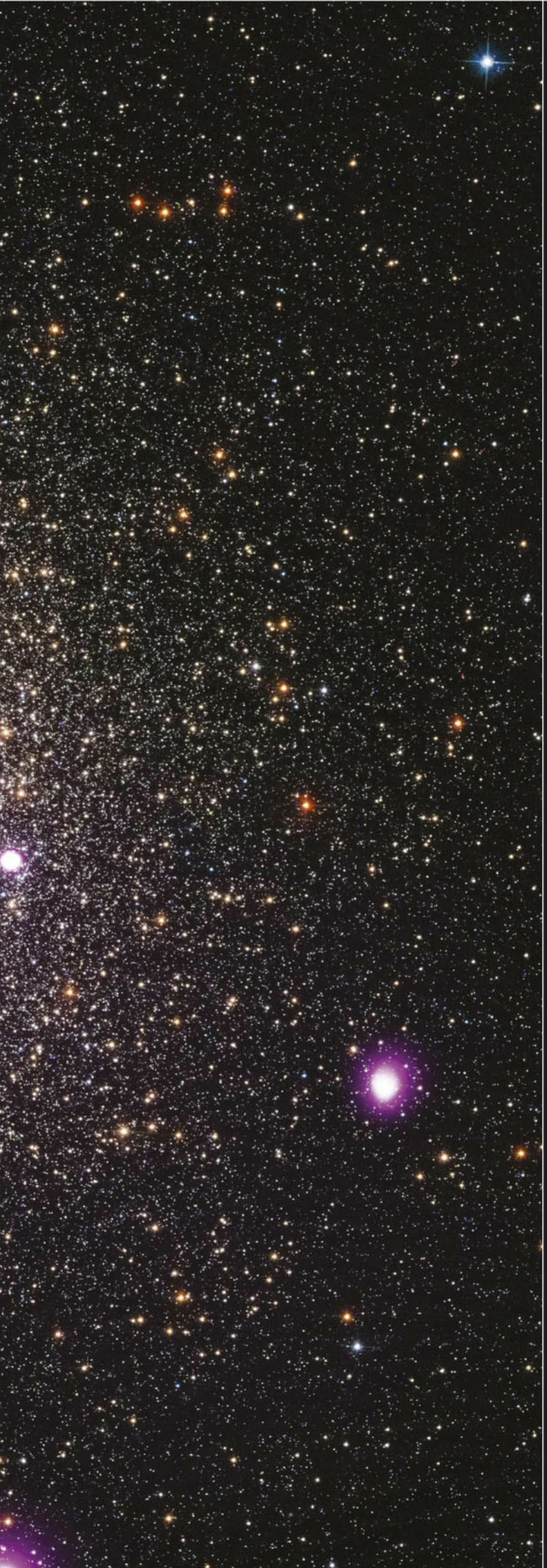




Tidal disruption

CHANDRA X-RAY OBSERVATORY, 16 APRIL 2015

Analyses of celestial bodies can often reveal clues about the cosmic events occurring around them

This composite image shows globular cluster NGC 6388 in Scorpius, with X-ray data from Chandra in pink overlaid on visible light data from the Hubble Space Telescope. In analysing the cluster, scientists have come to the conclusion that its X-rays are not coming from a black hole at its centre, but from a location off to one side. As the source became dimmer, theoretical models began to suggest that the X-rays had been caused by the shredding of a nearby planet, a tidal disruption event, as it passed too close to a white dwarf. This is not a watertight theory by any means, but was strengthened by data from multiple telescopes that enabled other explanations to be eliminated, including the fact that it is too faint in radio waves to be part of a binary system containing a stellar-mass black hole.

X-RAY – NASA/CXC/IASF PALERMO/M.DEL SANTO ET AL/OPTICAL: NASA/STSCI

▲ Staring at the stars

VERY LARGE TELESCOPE, ESO PARANAL OBSERVATORY, 27 APRIL 2015

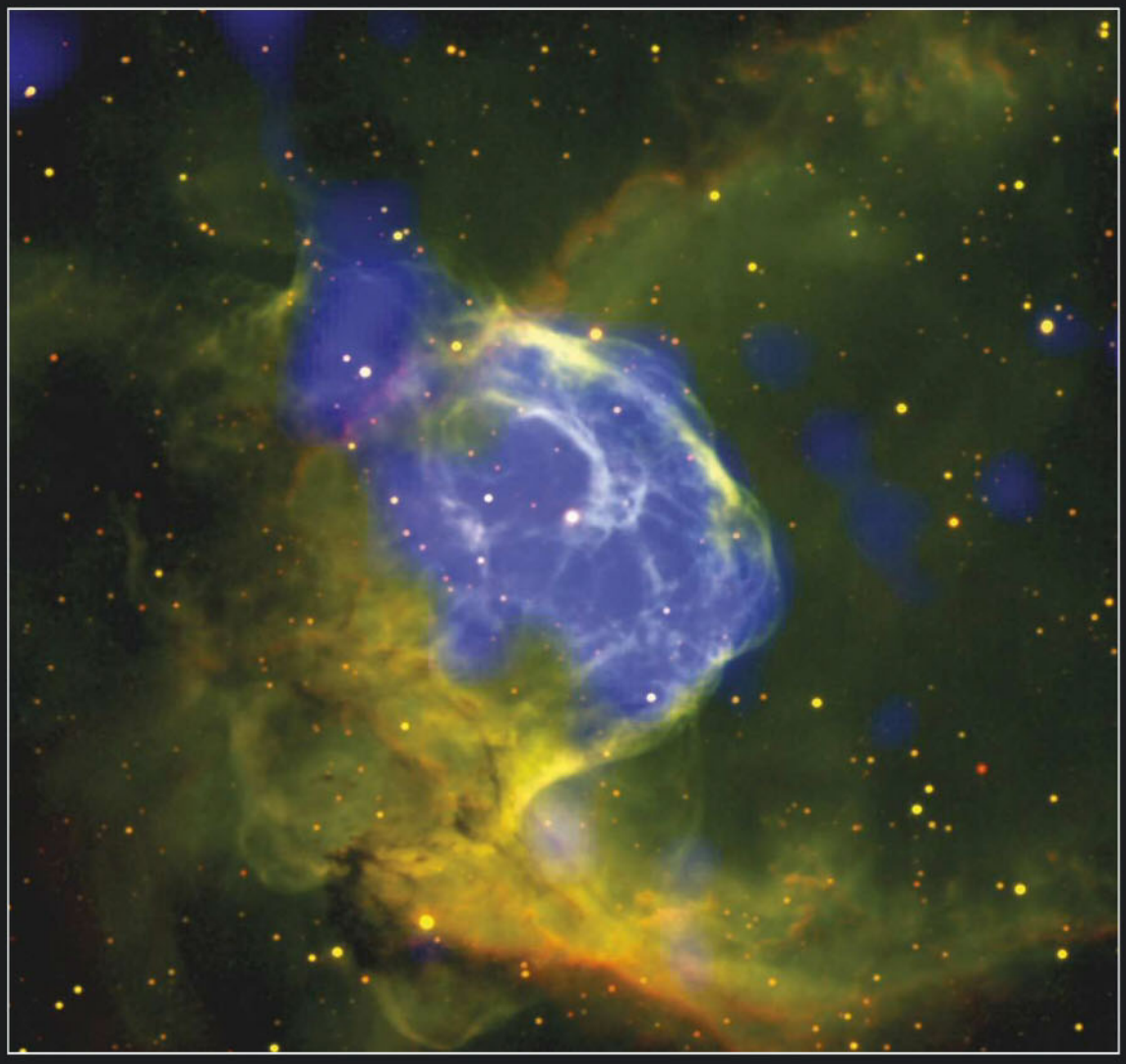
As the Sun sets on ESO's Paranal Observatory, the majesty of the Milky Way and its hundreds of billions of stars stretches out across the night sky. This picture shows the VLT's fourth Unit Telescope, known as Yepun.

Something peculiar ▶

HUBBLE SPACE TELESCOPE, 20 APRIL 2015

ESO 162-17 can be found about 40 million lightyears away in Carina. It is what's known as a 'peculiar galaxy' – one that has interacted with its neighbours to become irregular in shape and composition. In February, astronomers found supernova SN 2010ae nestled within it.

ESO/J. COLOSIMO, ESA/HUBBLE & NASA. IMAGE COURTESY OF J.A. TOALA AND M.A. GUERRERO (IAA-CSIC) Y.-H. CHU (UIUC/ASIAA) R.A. GRUENDL (UIUC) S. MAZLIN/J. HARVEY/D. VERSCHATSE AND R. GILBERT (SSRO-SOUTH) AND ESA, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE



▲ Norse nebula

XMM-NEWTON SPACECRAFT, 20 APRIL 2015

Also known as Thor's Helmet due to the distinctive shape of its blowouts and long filaments, emission nebula NGC 2359 is sculpted by the stellar wind of the star HD 56925 at its centre. The stellar wind generates a shock which, when combined with the circumstellar material, produces scorching plasma at temperatures over two million °C.

Capturing the gas giant ▶

CASSINI SPACECRAFT, 11 MAY 2015

This spectacular image of Saturn was taken from a distance of 2.5 million km by the Cassini spacecraft's wide-angle camera. It evokes a peacefulness that belies the planet's turbulent atmosphere, with winds blowing at nearly 1,800km/h.

Bulletin

The latest astronomy and space news written by **Hazel Muir**

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CUTTING EDGE
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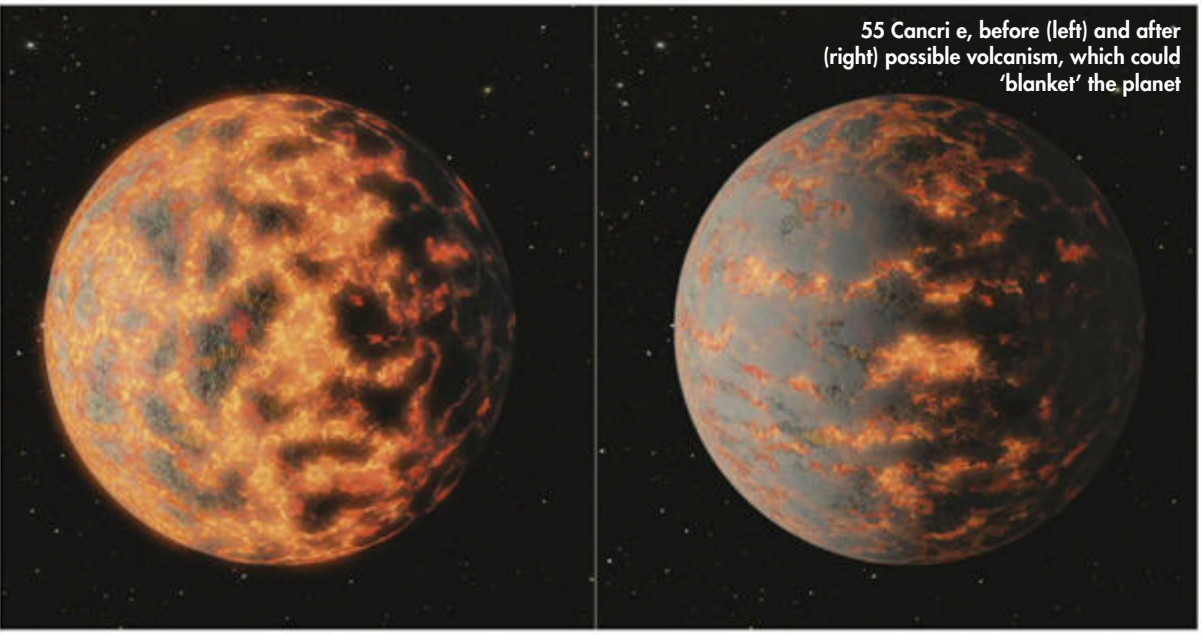
15 LEWIS DARTNELL

Our experts examine the hottest new astronomy research papers



55 Cancri e, before (left) and after (right) possible volcanism, which could 'blanket' the planet

NASA/JPL–CALTECH/R. HURT, ARRIGONI-BATTAIA & HENNAWI/MPIA, ESA/HUBBLE & NASA, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE

Volcanoes beyond the Solar System?

Eruptions could explain strange brightness changes on a distant super-Earth

ASTRONOMERS HAVE DETECTED dramatic atmospheric changes on a rocky planet far beyond our own Solar System for the first time. The planet in question, 55 Cancri e, is a super-Earth 40 lightyears away that endures wildly changing temperatures, which could possibly be due to volcanic activity.

The planet, roughly twice as wide as Earth and eight times as massive, orbits a Sun-like star and has been dubbed the 'diamond planet' because of speculation that it is extremely rich in carbon.

Observations made using NASA's Spitzer Space Telescope have revealed that temperatures on the tidally locked planet's day side swing between 1,000°C and 2,700°C over a two-year period. It's not clear why, but one key factor could be massive amounts of volcanic activity.

"We saw a 300 per cent change in the signal coming from this planet, which is the first time we've seen such a huge level of variability in an exoplanet," says Brice-Olivier Demory from the University of Cambridge, the study's lead author. "We think a likely explanation for this is large-scale surface activity, possibly volcanism, spewing out massive volumes of gas and dust, which sometimes blanket the thermal emission from the planet so it is not seen from Earth."

Demory's Cambridge colleague and study co-author Nikku Madhusudhan adds: "This is the first time we've seen such drastic changes in light emitted from an exoplanet, which is particularly remarkable for a super-Earth."

▸ **See Comment, right**

COMMENT
by Chris Lintott

Imagine a world, a little bigger than our Earth, in close orbit around its parent star. Its temperature is enormous, around a third as hot as the surface of the Sun itself, and so its atmosphere is wracked by enormous storms. The planet is locked so that one side permanently faces the star and the other cold, black space, leading to wave after wave of disturbances rolling across its surface.

This seems to be just as plausible an explanation as volcanism for what's being seen on this planet. Even Saturn, in our Solar System, shows enormous changes in brightness at some wavelengths during storms.

The authors of this new study aren't slow to recognise that alternative explanations exist. Indeed, they propose themselves that a lumpy doughnut of dust surrounding the planet, similar to that found around Io, could do the job. It's a fascinating world, but don't go expecting volcanoes just yet.

CHRIS LINTOTT co-presents *The Sky at Night*

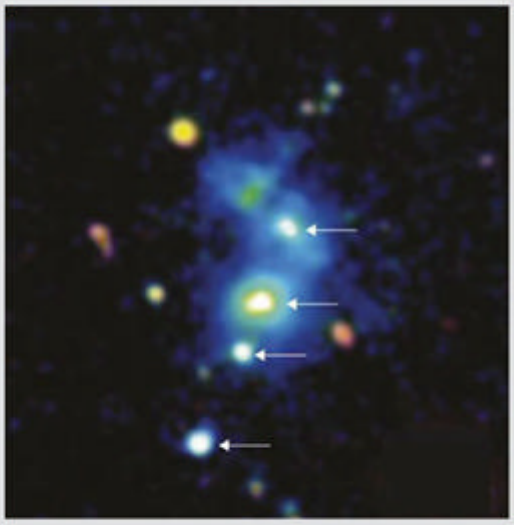
Astonishing quasar quartet found

The close-knit group of four energetic black holes defies expectations

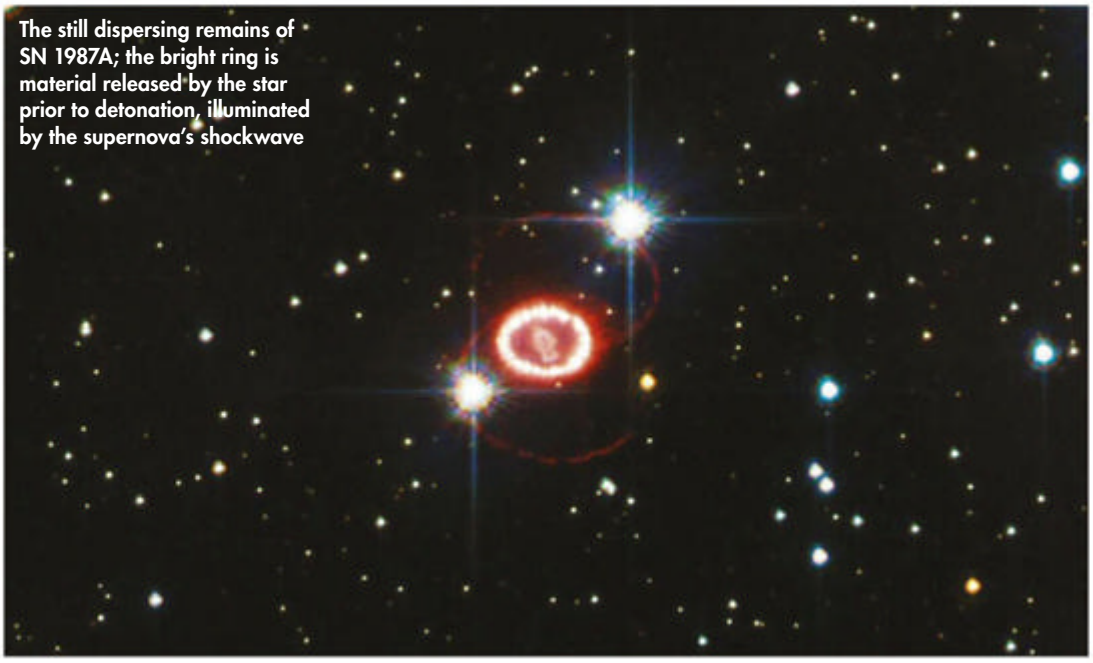
ASTRONOMERS HAVE DISCOVERED the first quadruple quasar – a rare set of four giant and active black holes in close proximity – using the Keck Observatory in Hawaii. If cosmologists have got their theories of quasar evolution right, the chances of this discovery happening randomly are just one in 10 million.

A team led by Joseph Hennawi from the Max Planck Institute for Astronomy in Germany discovered the four quasars embedded in a vast nebula of cool, dense gas. They are so distant that their light has taken nearly 10 billion years to reach Earth.

The discovery could force astronomers to rethink how quasars form and evolve. "Extremely rare events have the power to overturn long-standing theories," says Hennawi. "Either you just got very lucky, or you need to modify your theory."
www.keckobservatory.org



▲ **The four quasars, indicated by arrows, are embedded within a nebula of cool, dense gas**



The still dispersing remains of SN 1987A; the bright ring is material released by the star prior to detonation, illuminated by the supernova's shockwave

STELLAR EXPLOSIONS ARE SERIOUSLY WONKY

THE VIOLENT DEATHS of giant stars could be lopsided, with debris and stellar cores zooming off in opposite directions. Observations by NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) have proved this is true for supernova 1987A, the closest supernova to be detected in hundreds of years.

A team led by NuSTAR scientist Fiona Harrison from the California Institute of Technology studied radioactive titanium in the remnant of the supernova, seen to explode 168,000 lightyears away in 1987. Direction-dependent frequency changes in gamma rays showed most of the material in the remnant is moving away from us. It's the best proof yet that an asymmetrical mechanism triggers Type II supernovae, in which a very massive star's core collapses. Probably, the spherical star first transforms into a wobbly mass made up of turbulent plumes of hot gas.

"If you make everything just spherical, the core doesn't explode – you need asymmetries to make the star explode," says Harrison. The finding could clarify why some supernovae leave behind black holes, while others leave dense neutron stars.
www.nasa.gov/nustar

NEWS IN BRIEF

NEW HORIZONS CLOSES IN ON PLUTO

Bright and dark regions on the surface of Pluto have been revealed by NASA's New Horizons spacecraft, which will fly past the dwarf planet on 14 July. Pluto, shown below, seems to have broad surface markings, including a bright area at one pole, possibly a polar cap.

"We are starting to see intriguing features such as a bright region near Pluto's visible pole, starting the great scientific adventure to understand this enigmatic celestial object," says John Grunsfeld from NASA's headquarters in Washington DC.

EXOPLANET 'TOO BIG' FOR ITS STAR

A surprisingly giant planet orbiting a very small cool star 500 lightyears away is challenging ideas about how planets form. Astronomers discovered it using the international HAT-S project, which operates widespread small robotic telescopes.

"We have found a small star with a giant planet the size of Jupiter, orbiting very closely," says George Zhou from the Australian National University in Canberra. "It must have formed further out and migrated in, but our theories can't explain how this happened."

NEWS IN BRIEF

THE DARK SIDE OF GLOBULARS

A new class of 'dark' globular clusters has been found around the giant galaxy Centaurus A in observations made by the Very Large Telescope in Chile. They are inexplicably massive and may harbour surprisingly large amounts of dark matter or giant black holes.

Globular clusters are ancient balls of thousands of stars that orbit most galaxies. In a study of 125 globular clusters around Centaurus A, Matt Taylor from the Pontifical Catholic University of Chile and colleagues showed that some have many times more mass than their visible stars can explain.

WATER SOAKED THE EARLY COSMOS

Water, commonly thought to have been a relative latecomer to the Universe, may actually have become plentiful when the cosmos was just five per cent of its current age. Theoretical work by Shmuel Bialy from Tel Aviv University in Israel and colleagues suggests that stars created enough oxygen to manufacture water early. "This was very surprising and raises important questions about the habitability of the first planets – water is the key component of life as we know it," says Bialy.

ESO/ESA/HUBBLE/NASA. DIGITIZED SKY SURVEY. ACKNOWLEDGEMENT: DAVIDE DE MARTIN A. FEILD STSCI

Halo surrounds Andromeda

The gas cloud stretches halfway to our own Milky Way

SCIENTISTS HAVE DISCOVERED an amazingly vast halo of gas surrounding the Andromeda Galaxy, M31, the nearest giant galaxy to our own, using archived observations from the Hubble Space Telescope. The halo stretches a million lightyears out from M31, about halfway to the Milky Way.

The study suggests the gargantuan halo contains at least as much mass as half of the stars in M31, which contains about a trillion stars, double the number in the Milky Way. "Halos are the gaseous atmospheres of galaxies," says team leader Nicolas Lehner from the University of Notre Dame in Indiana. "The properties of these gaseous halos control the rate at which stars form."

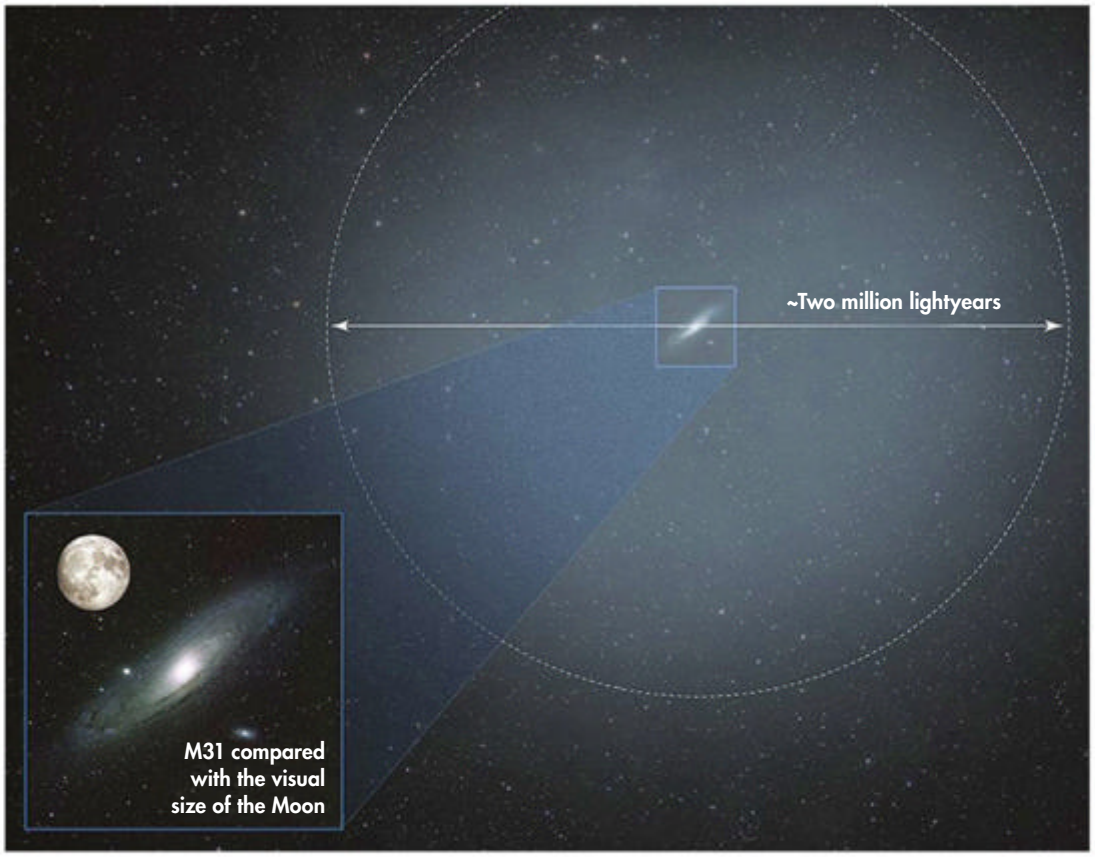
Lehner's team found that M31's gaseous halo has an apparent size about 100 times wider than the Moon. To detect it, they investigated how it altered the light from background quasars, energetic galaxies powered by matter falling onto giant black holes.

"As the light from the quasars travels toward Hubble, the halo's gas will absorb some of that light and make the quasar appear a little darker in a very small wavelength range," says team member Christopher Howk, also from the University of Notre Dame. "By measuring the dip in brightness, we can tell how much halo gas from M31 there is between us and that quasar."

Hubble has allowed astronomers to observe halos around other galaxies before. But the vast size of M31's halo meant that an unprecedented 18 background quasars highlighted its shape. "This is a new milestone because typically only one quasar is used to probe the halos of galaxies," says Lehner. "We have assembled a large sample of quasars that directly demonstrate the true extent of the halo of a single massive galaxy."

His team hopes to trawl further Hubble observations of quasars to find out how halo gas affects the evolution and structure of giant spiral galaxies. If the Milky Way possesses a similar halo to Andromeda, the halos of both galaxies could merge long before they collide due to their mutual gravitational pull, which will happen in around four billion years.

www.hubblesite.org



▲ The Andromeda Galaxy's halo spreads out by around one million lightyears in each direction

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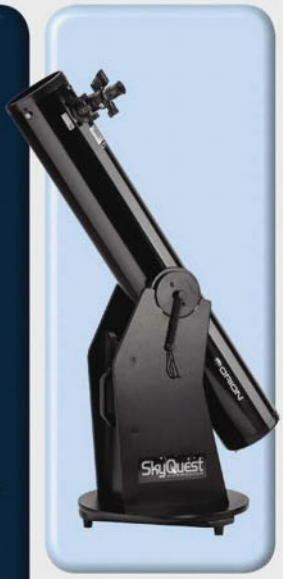

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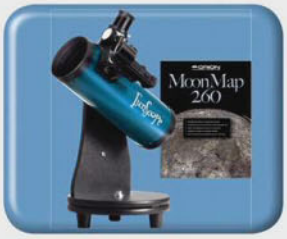

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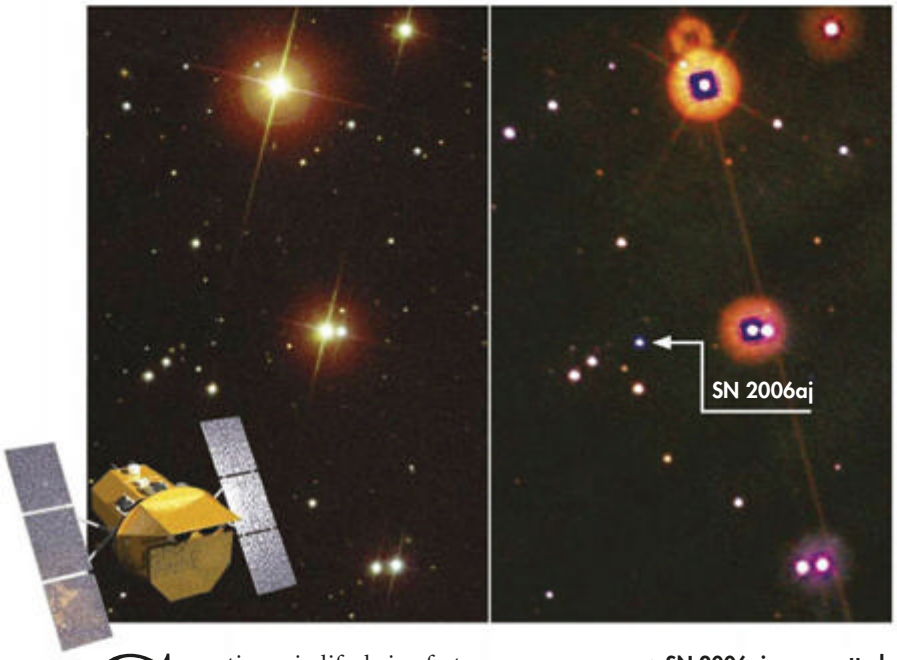


SDSS COLLABORATION/SWIFT COLLABORATION/SLOAN FOUNDATION/NSF/NASA, NASA'S GODDARD SPACE FLIGHT CENTER

▲ **SN 2006aj was spotted 440 million lightyears away in Aries. Left is the 'before' image of the region from the Sloan Digital Sky Survey, right is Swift's view of the event**

Sometimes, in life, being fast pays dividends. That's certainly been true for the Swift satellite, which for the past decade has been swinging around the sky in response to anything that goes bang. It's best known for helping pin down the cause of extreme explosions known as gamma-ray bursts, but has also observed more than 300 normal supernovae.

The key to the power of these observations is the sensitivity of Swift's cameras to the ultraviolet and X-ray regions of the spectrum. Supernovae that look identical if viewed in visible light look dramatically different through its eyes. The way a supernova fades in these more energetic regions of the spectrum depends dramatically on the composition of the star. Swift comes to the same supernova again and again, providing a detailed view of the first few weeks after the explosion itself.

A new paper has catalogued the very best of these supernovae – with 300 and counting, it's perfectly natural to have favourites. One of the most significant had the rather unimposing title of supernova 2006aj. It was first identified as a gamma-ray burst, which allowed Swift to quickly point at it and catch what's called the 'shock breakout'. Like most supernovae, 2006aj occurred when a massive star ran out of fuel at its core. It imploded, but that collapse caused a rebounding shockwave to ripple outwards through the star's atmosphere. This shock soon reached the surface of the star – this is the shock breakout – at which point the gas heated by its passage becomes visible, glowing brightly in the ultraviolet.

Swift's rapid dash to 2006aj meant it could observe the action, and it turned out that the shock breakout lasted longer than expected, leading astronomers to believe that there must have been a strong wind blowing from the surface of the star immediately prior to the explosion. The wind must have filled the surrounding space with gas dense enough for the shock to travel through.

This kind of detail would be hard to discover any other way, but we don't need to look at individual supernovae in great detail to find interesting results. Take Swift's observations of Type Ia supernovae, which are used to measure the expansion of the Universe. Given their importance, it's somewhat disconcerting to find they're not all the same.

Swift divides Type Ias into those which are 'blue' and those which are 'red' in the ultraviolet, a division that points to different underlying causes

> "Supernovae that look identical in visible light look very different to Swift's eyes"

– different types of star involved, perhaps. In the local Universe, 'red' ultraviolet supernovae are almost twice as common as their blue counterparts. However, in the more distant Universe this ratio changes, suggesting that different stars become Type Ia supernovae at different times in the Universe's history. As cosmology becomes more precise, we're going to need to understand these effects in much more detail, and to be able to adjust for them.

There are plenty more: almost every paragraph in the paper points to fascinating detail, and the consequences will still be being worked out long after Swift has fallen silent. These discoveries have often made news over the years, but seeing them all in one place underlies how significant the contribution of this one small satellite has been.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading…
The first ten years of Swift supernovae by Peter J Brown, Peter W A Roming and Peter A Milne
Read it online at http://arxiv.org/abs/1504.08017

What darkens Europa's surface?

The proposed sea salt on the moon could hold clues about its habitability

▲ The sea salt on Europa may have gained its now-famous ruddy hue through exposure to radiation

THE STRANGE DARK material coating young geological features on Jupiter's moon Europa could be sea salt that originated in a subsurface ocean, according to experiments run in a lab here on Earth. It may have been darkened by exposure to surface radiation as Jupiter's magnetic field accelerates electrons and ions onto the moon.

"If it's just salt from the ocean below, that would be a simple and elegant solution for what the dark, mysterious material is," says team leader Kevin Hand from NASA's Jet Propulsion Laboratory in California. It might also imply that the subsurface ocean is interacting with its rocky seafloor, one factor that would influence whether the moon is or has been hospitable to life.

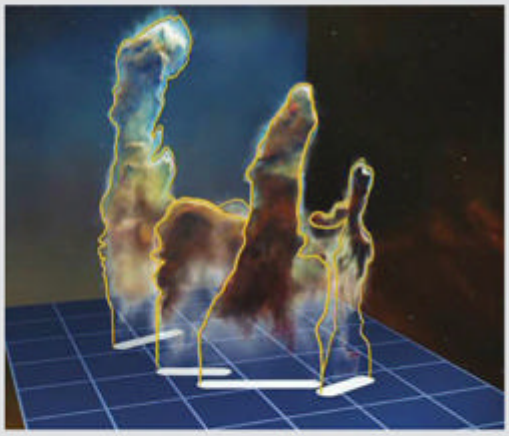
www.nasa.gov/jpl

PILLARS OF CREATION REVEALED IN 3D

THE FIRST COMPLETE 3D view of the famous Pillars of Creation in the Eagle Nebula, which lies about 7,000 lightyears away in the constellation of Serpens, has been created using observations from the Very Large Telescope in Chile. Intense radiation and stellar winds from a cluster of bright stars in the nebula have sculpted the dusty clouds there into exotic jutting structures.

The view shows the 3D distribution of the billowing clouds and highlights new features, including a previously unseen jet from a young star. Energy from the stars should fully evaporate the dusty pillars in about three million years.

www.eso.org/vlt



The 3D visualisation shows that the pillars are distinct entities on either side of star cluster NGC 6611

Looking back The Sky at Night

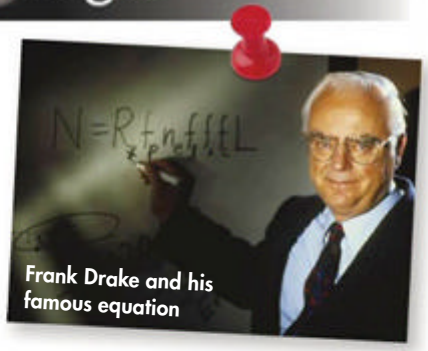
July 1965

On 23 July 1965 *The Sky at Night* broadcast discussed alien communication, with guests including Frank Drake, the American astronomer who has been an iconic pioneer in the search for extraterrestrial intelligence (SETI).

In 1961, Drake formulated the famous equation that calculates the number of intelligent extraterrestrial civilisations in the Milky Way capable of radio communications with Earth.

The 'Drake equation' factors in numbers including the fraction of stars with planets, the fraction of planets that develop life, and the fraction of those with life that eventually evolves intelligent life.

It's impossible to pin down very accurate values for any of these numbers, and some factors will remain anyone's guess. For instance, how easily do intelligent civilisations develop powerful radio transmitters, assuming they're so inclined? But Drake succeeded in his actual goal – inspiring interesting scientific debate and dialogue about SETI concepts.



Frank Drake and his famous equation

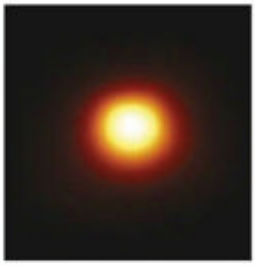
NEWS IN BRIEF

A MEGACLUSTER IN THE MAKING

An amazingly dense yet still star-free molecular cloud has been spotted by astronomers. It may be the first known example of a globular cluster in the process of forming.

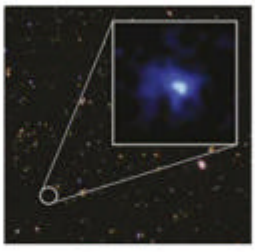
"We may be witnessing one of the most ancient and extreme modes of star formation," says Kelsey Johnson from the University of Virginia, whose team discovered the cloud in observations from ALMA in Chile.

"To discover something that has all the characteristics of a globular cluster, yet hasn't begun making stars, is like finding a dinosaur egg that's about to hatch."



GALAXY BREAKS DISTANCE RECORD

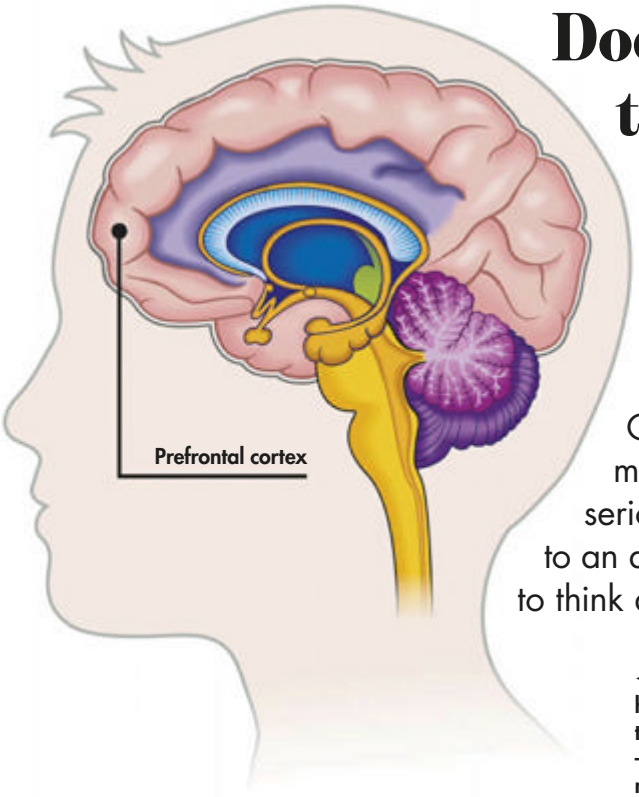
An exceptionally bright galaxy has broken distance records. Observations from the Keck Observatory in Hawaii have revealed that the galaxy lies so far away that its light has taken 95 per cent of the age of the Universe to reach Earth.



NASA/JPL-CALTECH/SETI INSTITUTE, ESO/M. KORNMESSER, DR SETH SHOSTAK/SCIENCE PHOTO LIBRARY, B. SAXTON (NRAO/AUI/NSF, NASA/ESA/P. OESCH AND I. MOMCHEVA (YALE UNIVERSITY) AND THE 3D-HST AND HUDF09/XDF TEAMS

CUTTING EDGE

Our experts examine the hottest new research



ISTOCK

Does space travel harm your brain?

Cosmic rays may cause serious damage to an astronaut's ability to think and remember

◄ The prefrontal cortex helps us to plan complex tasks and problem solve – both vital skills for a mission to Mars

Many of the hazards of human spaceflight are relatively well known, and we have a fair idea of how to mitigate them. For example, we can roughly calculate the probability of micrometeoroids or fragments of space junk hitting the International Space Station, and we design spacecraft with double walls to prevent hull ruptures as best we can. Likewise, the degenerative effects of microgravity on the human body, such as deterioration of the heart or postural muscles in the legs and lower back are understood, and so astronauts follow a strict regime of exercise while in space.

But other dangers of the space environment are not well understood at all, such as the effects of cosmic radiation. Radiation can be anticipated to cause mutations and an increase in the risk of cancer, or to turn the eye's cornea opaque. But one thing we really have very little idea about what happens to the brain after being irradiated for long periods.

Vipan Parihar and his colleagues at the University of California have been investigating exactly this. The type of particle radiation encountered in space is very different from that on the Earth's surface from radioactivity – cosmic rays are made up of extremely energetic, heavy nuclei (such as the nuclei of iron atoms accelerated close to the speed of light by supernovae). This means that energetic cosmic rays are exceedingly difficult to shield effectively against. The first crewed missions to Mars will not be able to avoid exposure.

The high energy of these cosmic rays makes them difficult to recreate in a lab. In essence, what Parihar's team did was stick mice in the beam-line of a particle accelerator to expose their heads to ion radiation and studied them six weeks later. The team tested how well the animals performed in telling the difference between patterns of objects that they have either seen before or were completely new. They found that even after receiving low doses, the exposed mice were significantly worse at these standard behavioural tests for recognition and memory. And this cognitive decline correlated with visible disruption of the branching structure of nerve cells in the brain and the synaptic connections between them when the scientists peered down the microscope.

> "We have little idea about what happens to the brain after being irradiated for long periods"

Parihar was actually able to map the radiation-wrought damage to the circuitry in the prefrontal cortex, an area of the brain that is crucial for functions such as planning complex behaviour, decision-making and problem solving. This is a huge concern because, unlike a calculated risk of increased incidence of tumours later in life, the brain seems to be especially vulnerable to radiation and developing long-term (if not even permanent) deficits in learning and memory; problems which could endanger the success of an entire mission.

Astronauts cannot train for every eventuality. The time lag for communications with Earth will mean that the crew on a Mars mission will need think for themselves to keep everything on track, or to respond appropriately to unexpected situations. After six months of irradiation on the way to Mars, an otherwise healthy crew could end up making catastrophically bad decisions.

LEWIS DARTNELL is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading…
What happens to your brain on the way to Mars
by V Parihar et al
Read it online at http://advances.sciencemag.org/content/1/4/e1400256

The Wonder of the Northern Lights

Viewing the magical aurora borealis in the Arctic Circle

The awe-inspiring spectacle of the Aurora Borealis (Northern Lights) has held watchers spellbound since the dawn of human history. Countless legends arose to explain these extraordinarily beautiful swirls of greens, yellows and reds shimmering against the night sky, from celestial dragons to the spirits of vanquished warriors. Knowing their scientific origin - as charged particles borne on solar winds to the earth's magnetic pole - in no way detracts from their magnificence or modern-day appeal. Our fascinating cruise itinerary, set entirely within the Arctic Circle aboard one of Hurtigruten's excellent vessels, maximises the likelihood of experiencing this mesmerising phenomenon.

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Day 2 Tromsø. After breakfast this morning, we are taken on an orientation tour of Tromsø. Its location gives you a good chance of viewing the Northern Lights. We are transferred in the late afternoon to embark your vessel, with time to settle in before dinner, and we begin our voyage north, keeping our eyes to the skies.

Day 3 Honningsvåg (North Cape). This morning, we arrive in Honningsvåg where you may choose to join an optional excursion to mainland Europe's most northerly point - the North Cape, where the cliffs rise dramatically 300 metres from the sea. This afternoon we sail on, calling at some pretty fishing villages.

Day 4 Kirkenes - Berlevag. We arrive in the sheltered harbour of Kirkenes, a mere 10km from the Russian border and the Sami communities of Northern Finland. Whilst here, there is the opportunity to join an optional excursion to visit the amazing Snow Hotel. Our adventure continues this afternoon as we sail southwards, crossing Varangerfjord, a fabled bird-watching site.

Day 5 Hammerfest - Tromsø. We sail along the beautiful leeward side of Mageroya Island to Honningsvåg, Hammerfest, Oksfjord and Skjervoy, before we arrive in Tromsø, where we disembark and return to the Radisson Blu Hotel for the night.

Day 6 Tromsø - London. After a leisurely morning, we transfer to Tromsø Airport for our scheduled Scandinavian Airlines flight to London Heathrow, via Oslo. On arrival you will be met and guided to your Titan vehicle, for the journey home.

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Category	Polarlys 16 February		Kong Harald 21 February	
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2	~~£1,799~~	£1,699	~~£1,799~~	£1,699

Category	Finnmarken 26 February		Finnmarken 8 March	
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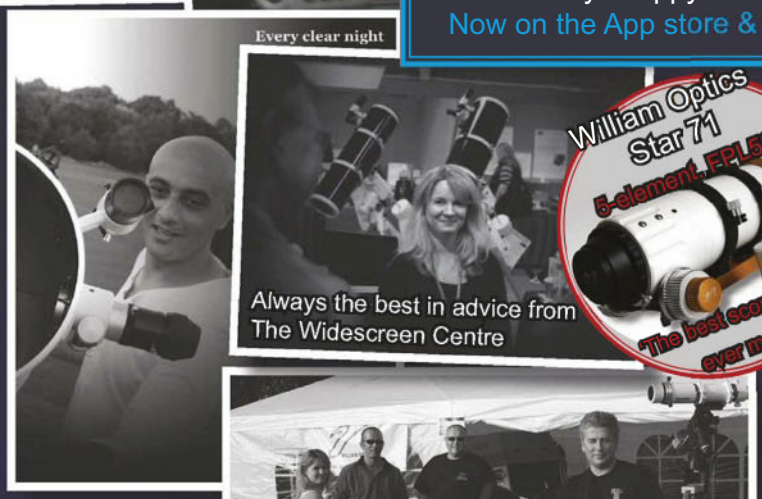

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Lunar photo by Widescreen customer Richard Maun. Main BSIA image by Tom Kerss. Sadr nebulosity by Geoffrey Lenox-Smith

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What's on

Our pick of the best events from around the UK

PICK OF THE MONTH

Sun Live Event

Hampshire Astronomical Group, Clanfield Observatory, Clanfield, 18 July, 2pm

Hampshire astronomers invite the public to catch the Sun with them this summer

HAMPSHIRE ASTRONOMICAL GROUP, PLYMOUTH UNIVERSITY, ARMAGH PLANETARIUM, NASA

On 18 July, the Hampshire Astronomical Group is offering the chance to observe the Sun's surface from the Clanfield Observatory in real time, behind the safety of solar filters.

Depending on weather conditions and the level of solar activity, visitors will have the opportunity to view prominences and sunspots through hydrogen-alpha scopes and other special observing equipment. In the event of bad weather, the society has arranged for a tour of the observatory and an illustrated talk on the Sun.

Clanfield Observatory has been a focal point for Hampshire astronomers for over 30 years and houses five domes with various grades of telescope, while the group's support building hosts presentations and training sessions. July's Sun Live event offers the chance to visit the observatory and view the astronomers in action, as they provide a glimpse into the world of solar activity.

Entrance is limited to pre-purchased tickets, priced at £5 for adults and £3 for under-16s, which can be obtained by completing the online booking form or emailing the society; for full details visit the link below.

hantsastro.org.uk/solardays

BEHIND THE SCENES

1 HOUR-LONG SPECIAL

THE SKY AT NIGHT IN JULY

BBC Four, **20 July**, 10pm (first repeat BBC Four, **date and time TBC**)*

New Horizons will map the surface composition of Pluto and nearby Charon

HELLO PLUTO

To mark *The Sky at Night's* 750th episode, we take you to New Horizons mission control near Washington as the probe encounters dwarf planet Pluto. No probe has ever visited Pluto before, and our 60-minute special will reveal all, following events across the week and giving insight to the unprecedented images sent back.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

50 Years of Martian Exploration

Plymouth Astronomical Society, Babbage Building, Plymouth University, 10 July, 7.30pm

Since NASA's Mariner 4 made its flyby in 1965, humanity has sent more than 30 missions to Mars, with more being prepared for the coming years. Planetary geologist Dr Natasha Stephen discusses the history of Martian exploration so far. The talk will look at real Martian samples, discuss the future of Mars science and ask what remains to be discovered. Admission is free for members and £2 for non-members.

www.plymouthastro.btck.co.uk

Beyond the Blue: A Stargazing Journey

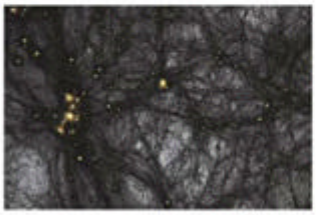
Armagh Planetarium, County Armagh, Northern Ireland, through July, 2pm

Armagh Planetarium resumes 'Beyond the Blue: A Stargazing Journey' in July, offering a seasonal tour around the night sky. The show will guide attendees through constellations and celestial objects and explain how to identify meteorites. Tickets are priced at £6 for adults, £5 for children/concessions and £20 for a family of two adults and three children.

www.armaghplanet.com

An Introduction to Cosmology

West Didsbury Astronomical Society, William Hulme's Grammar School, Manchester, 13 July, 7pm



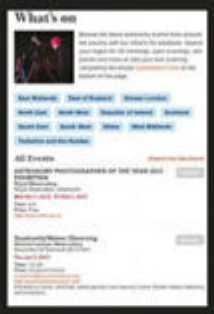
The West Didsbury Astronomical Society holds its annual general meeting, featuring an introductory talk on cosmology by Lingjie Kong, masters graduate in astrophysics from the University of Manchester. Admission is free to members and visitors.

www.wdas2.com

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.



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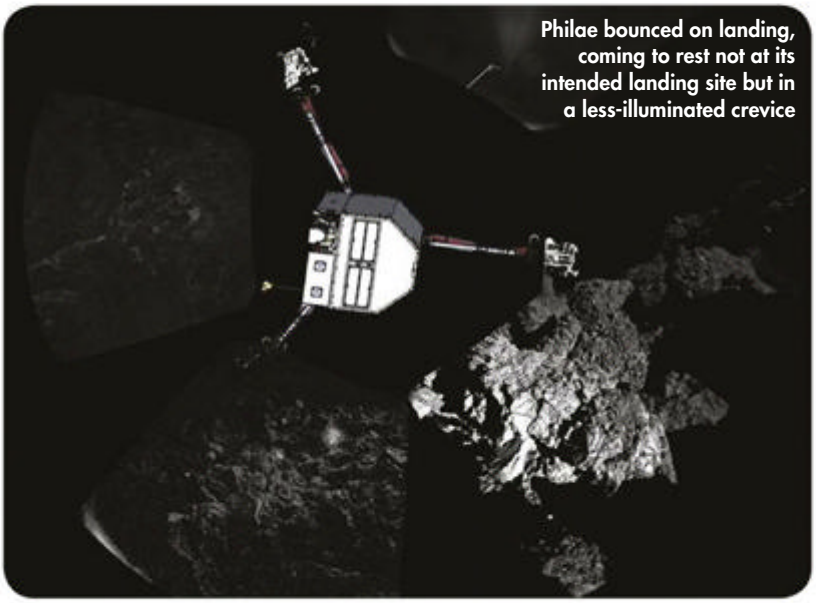
Astronomy Image by Chris Heapy

A PASSION FOR SPACE

with Maggie Aderin-Pocock

The Sky at Night presenter considers the awakening of Rosetta's Philae lander as its comet nears the Sun



Philae bounced on landing, coming to rest not at its intended landing site but in a less-illuminated crevice

ESA/ROSETTA/PHILAE/CIVA

Last year many of us were enthralled by the plight of the Rosetta mission's little Philae lander. Its landing turned into an extended bounce across the surface of comet 67P/Churyumov-Gerasimenko, finally coming to rest in a dark recess where illumination was limited. Scientists then battled to get as much data from it as possible before the onboard batteries were drained and the lander slipped back into hibernation. In the months that followed Philae's location was more or less established and it is thought now that Philae may soon come out of its sleep. But how likely is this to happen?

Its onboard computer has to reboot and two things are needed to enable this. First, the internal temperature of the lander needs to get above –45°C. Temperatures in space usually skirt around –270°C, so the lander was designed with heat absorption pads on its top surfaces to soak up thermal radiation, heating up its internal structure. Next, Philae's solar panels need to be generating at least 5.5W of power.

When Philae finally landed, after bouncing across the comet's surface, it was thought to have come down in a crevice or ravine where little radiation was reaching it. But now that the comet is closer to the Sun, the amount of radiation reaching Philae is significantly greater. And a change in the comet's orientation means that much more light should be reaching the lander's solar panels.

Waiting on sunshine

This period between June and September is when the lander is most likely to get the required light, so many of us are waiting – again with bated breath – to see if the Rosetta spacecraft picks up the signal and confirms that Philae is awake again.

Its location is not ideal for power generation, but this may work in its favour. If the calculated orientation is correct then the solar panels may only be illuminated for around two hours a day, rather than the original five hours that it would have received had it landed out in the open. Considering that, in the original plan, it was thought that this intense radiation would eventually blow the batteries, with the protection of its current location Philae could possibly survive much longer. This is of great interest to mission scientists as it means that they may be able study the comet through a far wider range of conditions as it comes closer to and then recedes from the Sun.

But things are still quite challenging. As the tethering harpoons did not fire when Philae finally came to rest, there is a possibility that increased comet activity approaching the Sun could see little Philae blown off the comet's surface by an erupting geyser of sublimating ices. But again, the shelter of its current location may save it from this fate.

So Philae is still throwing up many questions, but the next few months are sure to be exciting as this critical stage of the mission unfolds and we hopefully get some of the answers that we have been looking for.

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

SPECIAL EDITION

25 YEARS OF THE HUBBLE SPACE TELESCOPE

FROM THE MAKERS OF BBC Sky at Night MAGAZINE

Twenty-five years ago, the Hubble Space Telescope launched into Earth orbit and into the history books: it changed the way we view our place in space for ever. In this special issue, we celebrate the unparalleled clarity of Hubble's greatest images. With 116 pages of stunning galleries, plus features on the science Hubble enabled, the daring maintenance missions and more, you'll never see the Universe in quite the same way again.

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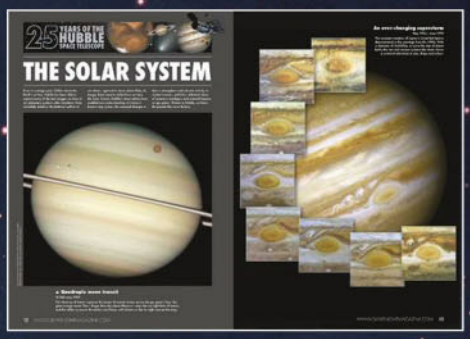

Stunning galleries of the very best images from the Hubble Space Telescope bring you the cosmos in all its glory

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Find out how mission technicians on Earth turn raw Hubble data into the clear, detailed images we know and love

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JON CULSHAW'S EXOPLANET EXCURSIONS

Jon contends with the clouds as he journeys to a Titanic gas giant in Centaurus

On 20 March I left my spaceship, the Perihelion, in the garage and boarded an ocean-going vessel, MS Boudicca, to see the total eclipse of the Sun from the surface of planet Earth. But as the morning began under leaden skies with stinging wind and sleet, I couldn't help feeling that I'd chosen the wrong craft. Thankfully, the collaboration of Pete Lawrence and Captain Lars Kjeldsen, who meticulously pooled their knowledge, guided us to clear skies at precisely the right moment.

We viewed the partial phases through stubborn, narrow cloud breaks resembling cracks in dried mud flats. It felt like we were fighting a toe-to-toe war of attrition with awkward clouds, reluctant to allow more than fleeting glimpses to be seen. Nerve-shreddingly exhausting as this was, it was worth every fragment of anxious hope when the clouds parted, allowing the majesty of totality to be seen. It felt like a miracle.

Enthused by the experience, I'm setting off to view far more distant objects through tantalising gaps in the cloud formations wrapped around exoplanetary worlds. There's a good chance of witnessing just such an evocative scene in Centaurus, around the star HD 113538, a sub red dwarf 65 per cent the mass of the Sun and 51 lightyears from Earth. Two confirmed planets orbit this star, with the tidy names HD 113538 b and HD 113538 c. I'm taking the Perihelion to the farthest of these, planet 'c' on the edge of the habitable zone.

HD 113538 c is a gas giant around 70 per cent the mass of Jupiter, orbited by numerous moons. As the planet is so Saturnesque I'm going to choose the satellite that is most Titanesque as our place to view the planetary neighbourhood. Evocative of our battle to glimpse as much of the eclipse through a barrel roll of uncooperative clouds, there's a similar situation here on the surface of this moon. Noxious clouds with patchy backlit regions loop and whirl across the alien sky, drawing a veil over the world. Hanging there like the bronze-coloured cigarette fog in a 1960s jazz club, these clouds create a tantalising sense of anticipation as I wonder what might end up being revealed.

Suddenly a family of five moons, all in a crescent phase, break through. Their sizes reduce like satellite Russian dolls. Through a suddenly thinning blanket of cloud there's a breathtaking view of the parent planet, HD 113538 c. It glows with the same crescent as the moons, occupying the sky like a planetary mother duck with her ducklings close by.

Then the most staggering feature of all snaps into view. This moon's very own ring system is revealed. A stark set of parallel lines like four silvered racetrack lanes slice upwards and loop back down after reaching their peak. There's surely no more astonishing way to view a ring system than from the surface of the object they surround. Seeing the rings backlit after the star sets is going to be a most ethereal sight. I'm grateful that the clouds are parting and the view of these remarkable objects won't be squandered all at once.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON; PHOTO: EMMA SAMMS

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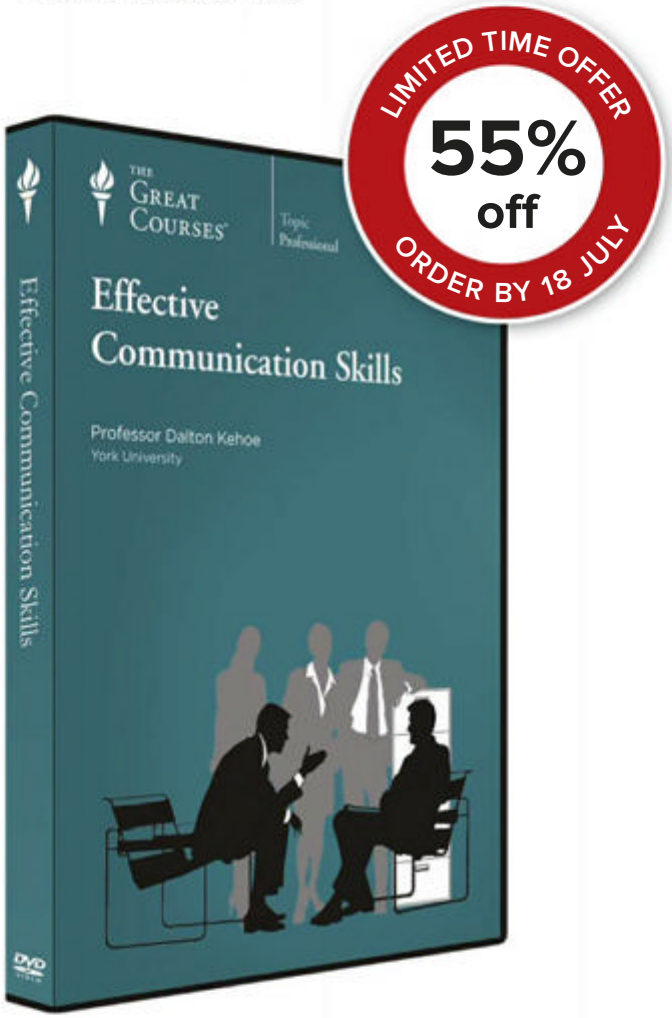

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This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Heather Couper and Nigel Henbest's *Stargazing 2015*, Patrick Moore's *The Night Sky*, Storm Dunlop's *Practical Astronomy*, and *Stargazing with Binoculars* by Robin Scagell and David Frydman.

PHILIP'S

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: What observing accessory do you value most?

@sjb_astro: It's got to be my fur-lined walking boots – I find it hard to do winter astronomy with cold feet!

@deepskymike: A very detailed sky map to help show exactly where those pesky 13th-magnitude galaxies reside.

Peter Sculthorpe: Velcro tape – it's way handy for keeping wires neat, and handset controllers handy!

@JP_Astronomy: A red light torch. It's always handy and doesn't ruin your eyesight when observing the night sky.

@19burly68: My polarscope illuminator.

NASA/JPL-CALTECH/MSSS

MESSAGE OF THE MONTH

Upcycling comes to astronomy

After reading your useful tips on stabilising binoculars I realised there was life in two spare tripod legs, which are all that's left from my starter scope after being broken in pursuit of our errant cat. The legs were too flimsy to reuse and a mini Dobsonian mount holds my newer grab-and-go scope. But a length of wood, some camping mat and half an hour's work later, I have an infinitely adjustable and – importantly – comfortable 'bino perch'. This is a joy to use with my 10x50s: I can dash up to the roof to lounge on a sunbed under the Mediterranean stars in a way that even my grab-and-go couldn't possibly match. I've managed to recycle (or is that upcycle?) an underperforming tripod. Thank you for the inspiration and a great magazine. The monthly *Binocular tour* just took on a whole new importance, and counts nicely towards the case I am constructing to justify the purchase of a better pair of binoculars!

Jim Wightman, St Julians, Malta

Jim turned his tripod into this 'bino perch'

Your description of observing under balmy Mediterranean skies has filled the office with envy, Jim! A job well done, that is upcycling for sure. ***– Ed***

Selfie suspicion

I thought the news item in the February 2015 issue about methane spikes in Mars's atmosphere ('New hints of life on Mars', page 12) was very interesting. Even more interesting was wondering who or what took Curiosity's picture in the illustration. I see no mast holding the camera. I am guessing the pic is a mosaic and NASA just took it out.

Bill McLean, via email

This picture is a conspiracy theorist's favourite, Bill! It is indeed a mosaic of several images, taken by the MAHLI camera on Curiosity's robotic arm. You can see the arm coming forward in the centre of the photo, and since the camera can't take a picture of itself, some clever editing was needed to tidy up the final image. ***– Ed***

A room with a view

Two months ago my family and I were in the Kettlewell area of the Yorkshire Dales. At night we had clear skies so I showed my granddaughter the Moon. As she was just 17 months old, I didn't really expect the level of interest that followed: she asked for the Moon day and night. When it wasn't on view the only option was to use my copy of *BBC Sky at Night Magazine*. She visited us a week or two later and headed straight for a pile of magazines, pulling out *BBC Sky at Night Magazine* and saying "Moon". From then on I've been greeted by the same request every time I see her. I decided to take a picture of the Moon (pictured below) to hang in her bedroom using a Tamron 70-300mm telephoto lens and a Canon EOS 7D DSLR. I followed April's *Image Processing* article ('Introduction to Levels', p85), in particular the section about the midtone slider. This really helps to bring out the details, and I was pleased with the result. Thanks very much for this useful article and others like it, which help to make astrophotography so much more accessible to beginners like me.

Michael Tempan, Lancashire

A wonderfully inspiring story, Michael, and it's great to see our image processing advice put to such good use. ***– Ed***

OOPS!

In June's feature on the general theory of relativity ('After Einstein', page 71), we said the Gravity Probe A mission revealed time passes slower in lower gravity. Time actually passes faster in lower gravity.

BBC

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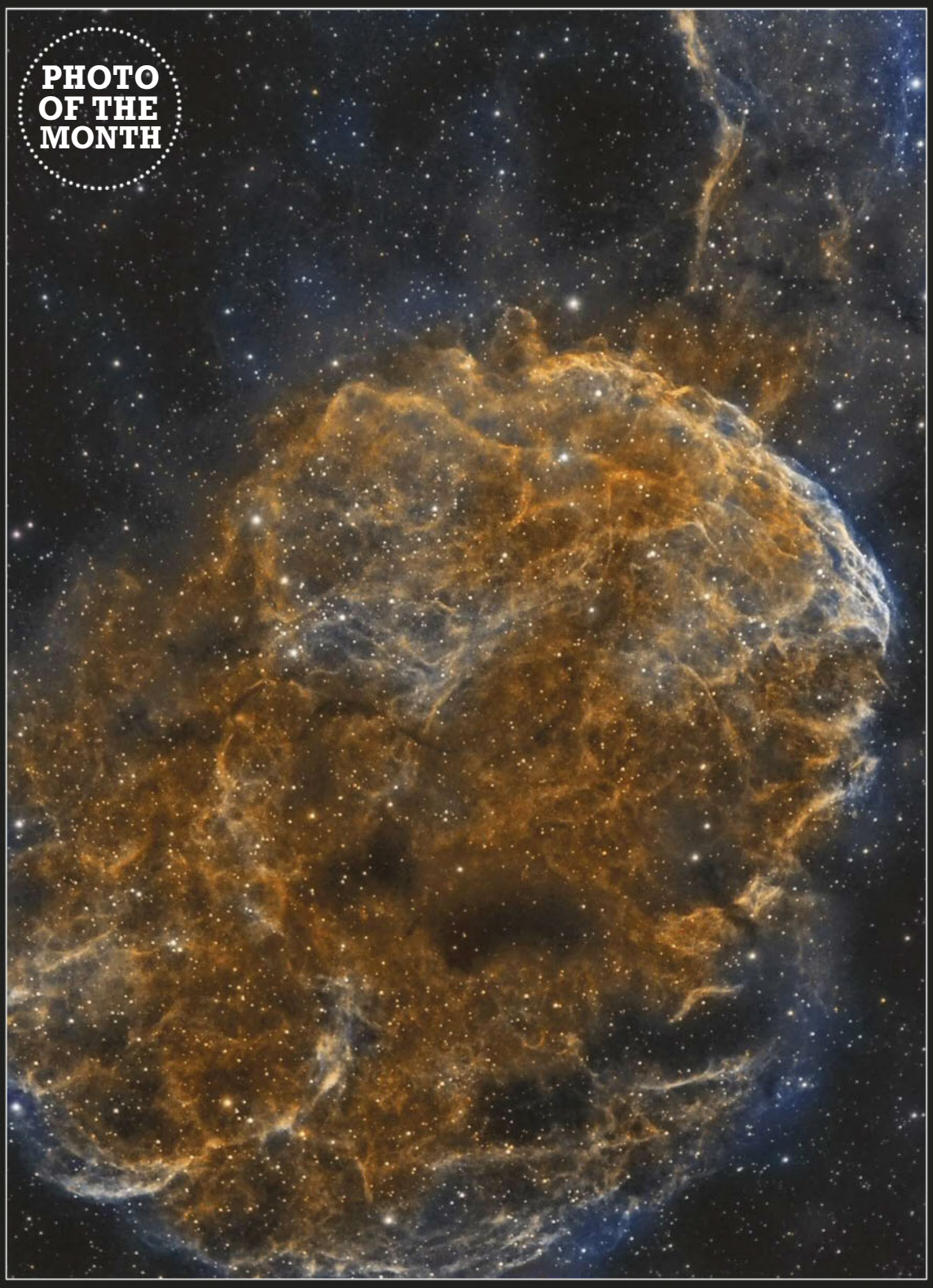
Hotshots

This month's pick of your very best astrophotos



◀The Jellyfish Nebula

JUAN IGNACIO JIMENEZ, SPAIN, 14 APRIL 2015

Juan says: "The challenge in capturing the image was to accentuate the OIII emission emanating from the nebula and correctly define the inner filaments."

Equipment: QHYCCD QHY9M mono CCD camera, TS 127/950 telescope, Sky-Watcher AZ-EQ6 mount.

***BBC Sky at Night Magazine* says:** "The vibrant contrast between the dusty browns and oranges, and the vivid blues and blacks surrounding the nebula make for a stunning image."

About Juan: "I have been taking photos of astronomical objects for two years. I have loved astronomy since childhood, but I never got round to buying equipment until my wife gave me an old EQ6 and Celestron C8. My favourite objects to take pictures of are emission nebulae."

◀ Aurora borealis

JOHN CHUMACK, ALASKA, US, 17 MARCH 2015

John says: "This image was taken north of Fairbanks, in Alaska. On the evening of St Patrick's Day the sky erupted with incredibly bright aurora borealis that lasted all night long; after midnight it got so bright it turned the snow green!"

Equipment: Canon EOS 6D DSLR camera, 24mm f/2 lens.

▲ The Lyrid meteor shower

JOHN SHORT, TYNE AND WEAR, 22 APRIL 2015

John says: "Capturing meteors cannot be left to manual exposure. I was able to automate the process using Magic Lantern software."

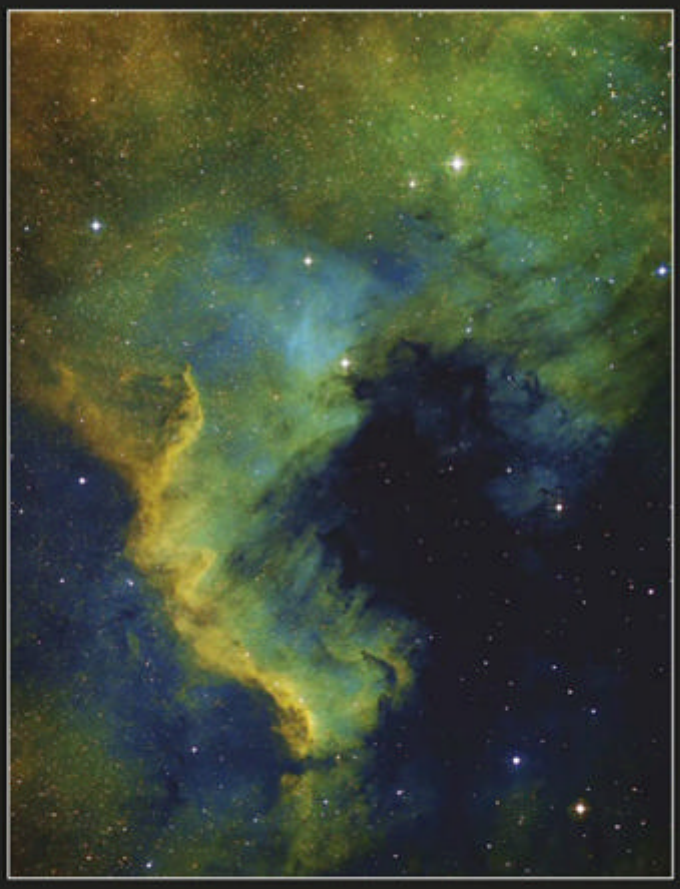
Equipment: Canon EOS 6D DSLR camera, Canon 8-15mm fisheye lens, Magic Lantern software.

▼ The North America Nebula

MARK GRIFFITH, SWINDON, 12-14 APRIL 2015

Mark says: "This is the emission nebula in the constellation Cygnus that resembles the shape of the North American continent. It is a Hubble palette image that worked well to reveal great detail. I rotated my camera by 90° to capture as much of the nebula as possible. The data was collected over three nights."

Equipment: Atik 383L+ CCD camera, Boren-Simon PowerNewt 8-inch astrograph, Sky-Watcher EQ8 mount, Astronomik SII, Ha and OIII filters.



The Elephant's Trunk Nebula

CHRIS HEAPY, MACCLESFIELD, 23 APRIL 2015

Chris says: "This shot is the result of both impatience and some early morning sessions – 'early' meaning between 2.30am and 5.00am on four nights. It is a narrowband composite using three filters that pass Ha, SII and OIII, mapped to the green, red and blue channels respectively. Each channel consists of eight 20-minute sub exposures giving a total of around eight hours."

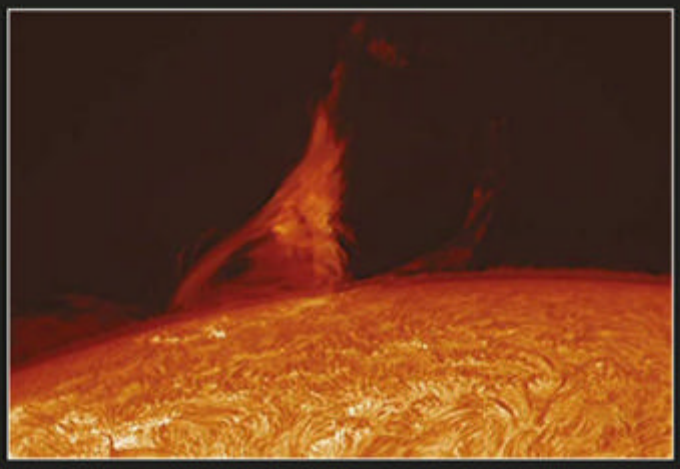
Equipment: Atik 490EX CCD camera, Tele Vue NP127is refractor, Losmandy G11 mount, Tele Vue Pronto refractor, Lodestar autoguider.

▲ Five years of Saturn

TOM HOWARD, SUSSEX,
TAKEN OVER FIVE YEARS ENDING 15 APRIL 2015

Tom says: "As well as showing Saturn's increasing tilt from Earth's point of view between 2011 (top left) and 2015 (bottom right), this compilation also documents my progress in planetary imaging during these five apparitions using a variety of telescopes, cameras and imaging techniques."

Equipment: Celestron Skyris 618C CCD camera, Celestron C11 Schmidt-Cassegrain telescope, EQ6 mount.



▲ Explosive solar prominence

GRAHAM GREEN, WATERLOOVILLE, HAMPSHIRE, 21 APRIL 2015

Graham says: "This was a very short-lived explosive prominence I caught at 02:17 BST. A magnetic filament rose up on the Sun's eastern limb, creating a prominence. I decided to run several videos of the event, hoping to catch a window of steady air (2,000 frames at 125 frames per second). This shot was the best of the lot but it needed extra work in post processing."

Equipment: Point Grey Research Flea3 CCD camera, Lunt Solar 4-inch hydrogen-alpha telescope, Sky-Watcher NEQ6 Pro mount.

▼ The Bubble Nebula

JASPAL CHADHA, LONDON,
14 JANUARY 2015

Jaspal says: "This shot is composed from narrowband image data, recording emission from the region's ionised hydrogen and oxygen atoms. I was able to sharpen the image and bring out more detail using CCDStack's deconvolution tool. I then recreated the Hubble palette colours by mapping the SII, Ha and OIII data respectively to the red, green and blue channels."

Equipment: QSI 690 CCD camera, Altair Astro RC250-TT telescope, iOptron CEM60 mount.

▲ NGC 6791

DAN CROWSON, MISSOURI, US, 26-28 APRIL 2015

Dan says: "NGC 6791 is an open cluster about 13,000 lightyears away in Lyra. I imaged it from my Bortle red zone [light polluted] driveway in Dardenne Prairie, Missouri, approximately 50km from St Louis over three mornings in April."

Equipment: SBIG ST-8300M CCD camera, Astro-Tech AT90DT.

◀ Night in the caldera

PETER LOUER,
TENERIFE, SPAIN,
23 APRIL 2015

Peter says: "I thought the magnificent rock formations in the caldera would make a good foreground for a nightscape. The Moon was just right to allow the night sky to show up, with enough light for foreground detail."

Equipment:
Canon EOS 700D DSLR camera, 18-55mm lens.

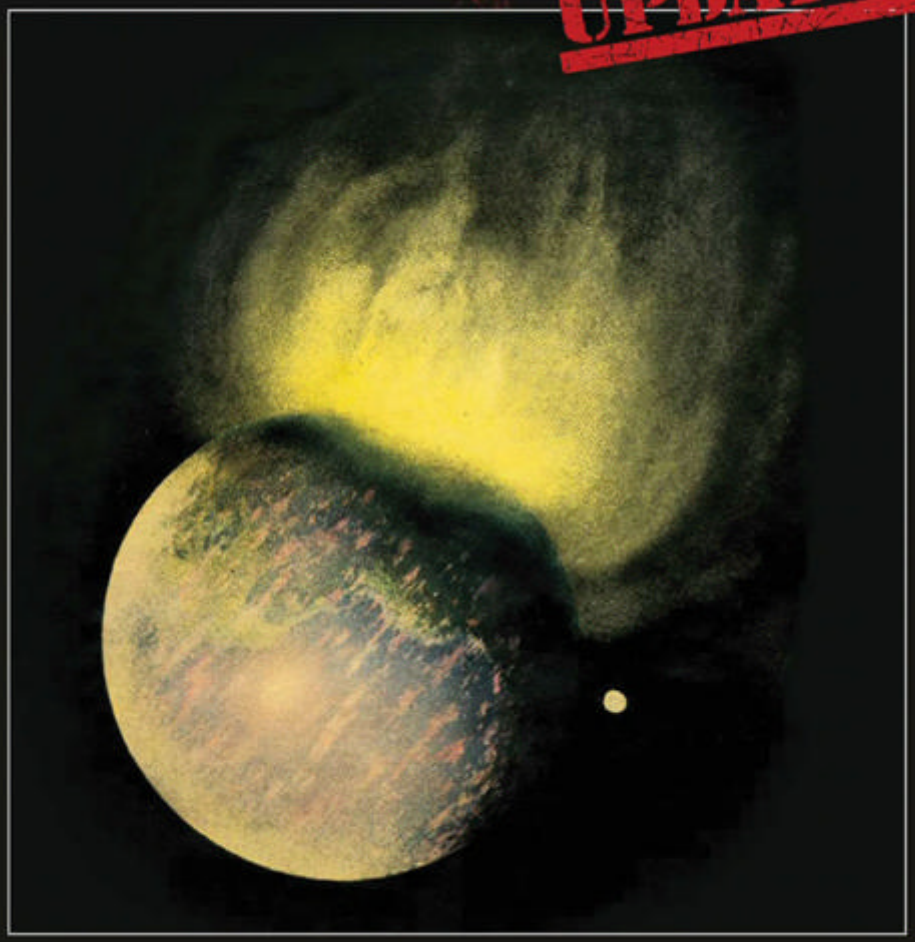
THE END OF THE WORLD UPDATED

Mark Garlick revisits some of the most famous artistic visions of the apocalypse

Almost 70 years ago, in July 1947, an American weekly digest magazine called *Coronet* published an illustrated article called 'The End of the World'. Prompted by the terrors of Hiroshima just two years previously, it outlined several scenarios in which planet Earth, according to the opinion of the experts of the period, could plausibly come to a sticky end.

The article featured eight possibilities, each of them beautifully illustrated by Chesley Bonestell, considered by many to be one of the fathers of astronomical art. Here we look back on those images and their original captions. With a better understanding of physics and astronomy, we now know that while some of these imagined catastrophes are plausible, others are unlikely, even a little outlandish.

▲ The end of world scenarios as they appeared in *Coronet* nearly 70 years ago



△ A COMET DESTROYS THE EARTH

***Coronet* caption:** When the atom bomb shattered Hiroshima two years ago, it reopened the haunting question of annihilation. But even before physicists developed the atom bomb, astronomers knew of greater, if less immediate, threats to world safety. To bring you some of the results of their research, *Coronet* commissioned Chelsey Bonestell, an artist and amateur astronomer, to make the paintings on the following pages. In the opinion of experts, these are some of the catastrophes which may someday plunge the Earth into chaos. Here, a small comet, 10,000 miles in diameter, smashes into the Earth.

We say: The caption to this image describes a comet 10,000 miles (16,000km) wide. The author must be referring to the size of the comet's coma here; even in the 1940s we knew that comet nuclei were only a few kilometres across. Comets of this size have presumably hit Earth many times in the past, and they will continue to do so as long as there are comets. That's countless billions of years. The impact of a large comet could easily trigger a mass extinction; in one fell swoop human civilisation would go the way of the dinosaurs.

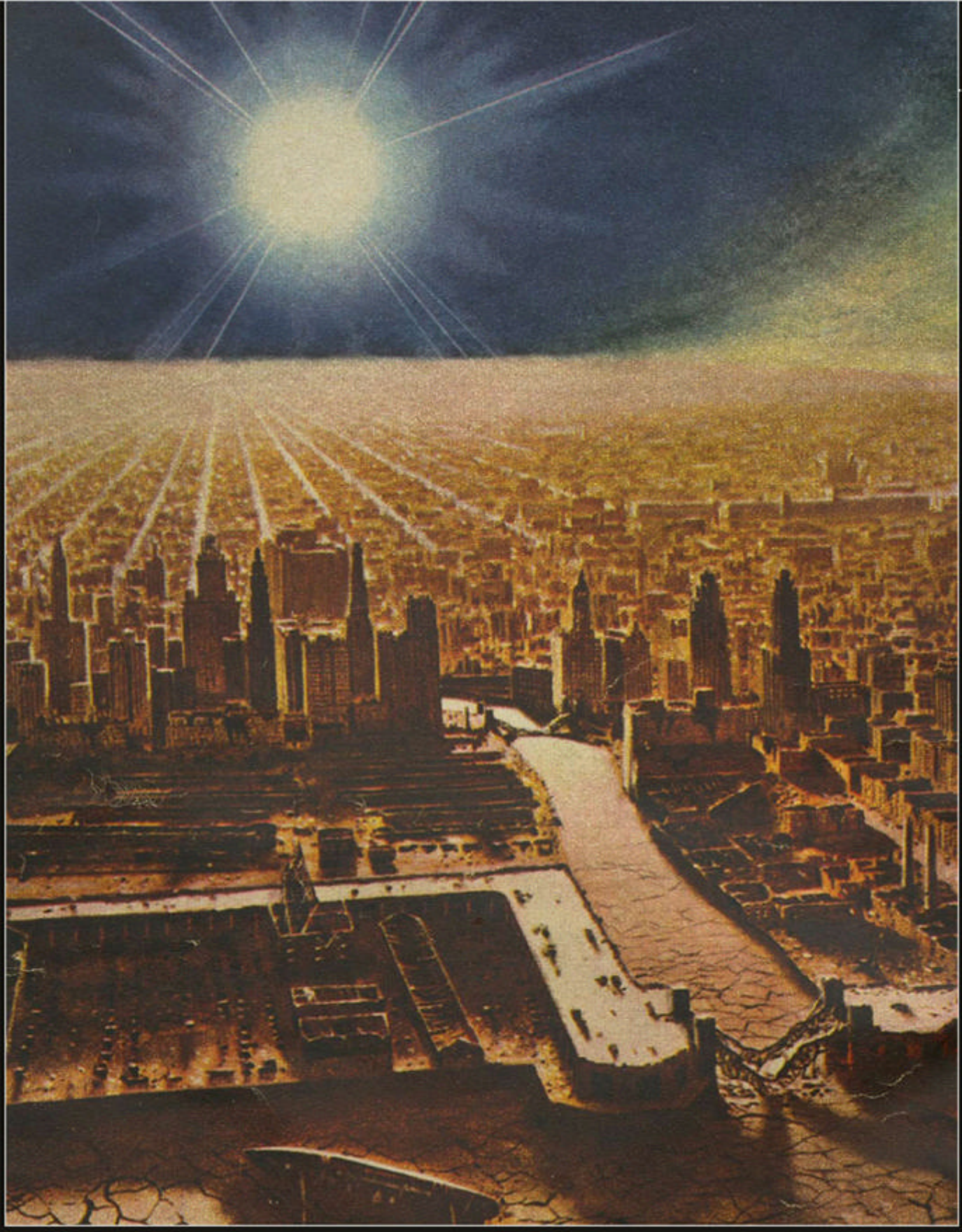
What are the chances?
With time, 100 per cent.

△ BATTLE OF GRAVITY

***Coronet* caption:** The stars travel at such tremendous speeds and in so many different directions that someday one might enter our Solar System. Such a possibility is illustrated in this picture, where a white dwarf star has come dangerously near the Earth. The gravitational force of white dwarf stars is so much faster than our own that people, buildings, ships – every moveable object on Earth – are hurtling irresistibly toward it. In a few minutes, our planet, and possibly the whole Solar System, will be entirely disintegrated.

We say: Space is incredibly empty: it's not called 'space' for nothing. If we shrank the Milky Way so that the Sun were reduced to the size of a pea, its nearest neighbours would still be several hundred kilometres apart. Because of this, collisions between stars in galaxies are exceptionally rare, and the chances of a white dwarf passing through the Solar System and wreaking havoc with Earth's gravity are vanishingly small. For a white dwarf to begin to destroy our planet it would need to come within about 90 Earth radii – that's beyond the Moon's orbit by half the average distance from Earth to the Moon.

What are the chances?
Minuscule; less than 0.1 per cent. ▸



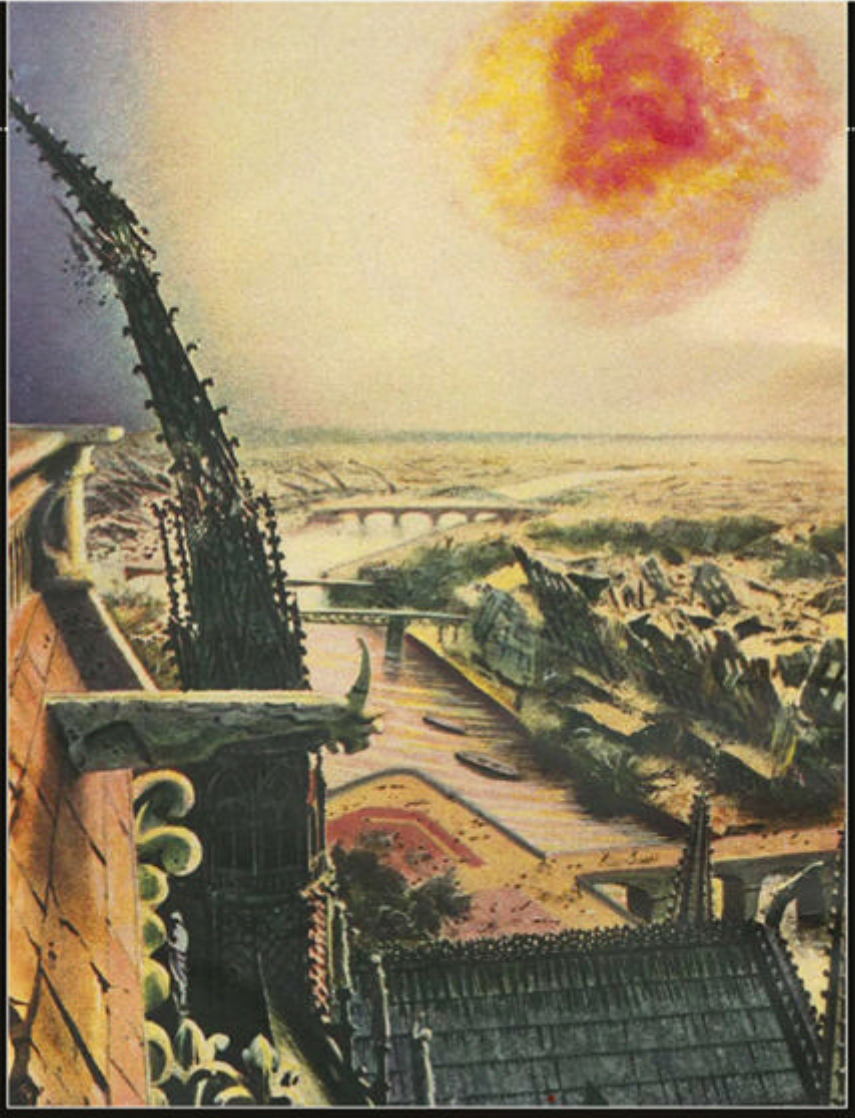
△ REVOLT OF THE SUN

***Coronet* caption:** According to astronomers, internal disturbances may suddenly cause the Sun to expand to as much as three times its normal size (above). The resulting increase in heat would then raise the temperature of the Earth to about that of melting lead. Here, you see the disastrous effect of the Sun's expansion on just one city – Chicago, Illinois. Lake Michigan and the Chicago River have boiled away. Life is extinct. Conditions everywhere on Earth are now similar to those on the planet Mercury.

We say: Some stars pulsate, changing their sizes – and, as a result, flare up and down in luminosity. Life on a planet around such a star would be hard pressed to get started. But the Sun exhibits only the tiniest amount of variability: its energy output changes by just 0.1 per cent over the 11-year solar cycle.

According to today's theories of stellar evolution, there are none of the 'internal disturbances' referred to in 1947, the alleged source of the sudden and drastic changes in the Sun's diameter and power. Only billions of years from now, when the Sun has grown larger with age, will our oceans start to evaporate.

What are the chances?
It's not going to happen; 0 per cent.



◁ WAVES OF PRESSURE

***Coronet* caption:** When the asteroid Hermes crossed the Earth's orbit in February 1938, it missed us by only 485,000 miles and did no damage. But if Hermes or a similar small planet should ever come as close as the one in this picture, the tremendous pressure wave it created would flatten everything in its path. In this view of Paris from behind the Cathedral of Notre Dame (left), you see the famous French city collapsing like a house of cards, as an asteroid (upper right) cuts a path of destruction across the Earth.

We say: In February 2013, a chunk of space rock the size of a bus raged through our atmosphere at 20km/s and exploded about 30km over Chelyabinsk, Russia. The shockwave shattered windows and damaged property. Had this bolide been much bigger with a shallower trajectory, it could have bounced off our planet's atmosphere and back out into space, generating shockwaves that might indeed have been able to flatten a city. However, it's more likely that a asteroid with our name on it would hit the surface itself. Actually, Hermes made its close pass of Earth in October 1937, not February 1938 as stated in *Coronet*. Hermes was 'lost' after its 1937 appearance; upon its rediscovery in 2003, astronomers calculated that it also made close approaches in 1942, 1954, 1974 and 1986.

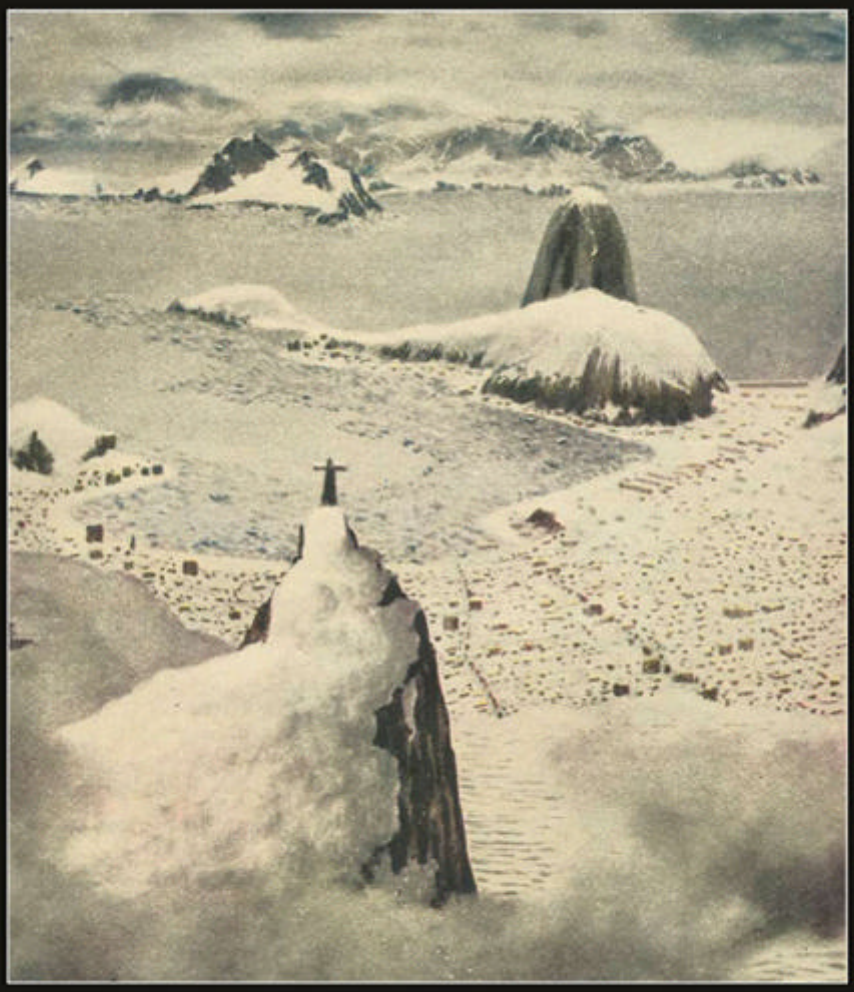
What are the chances?
With time, 100 per cent.

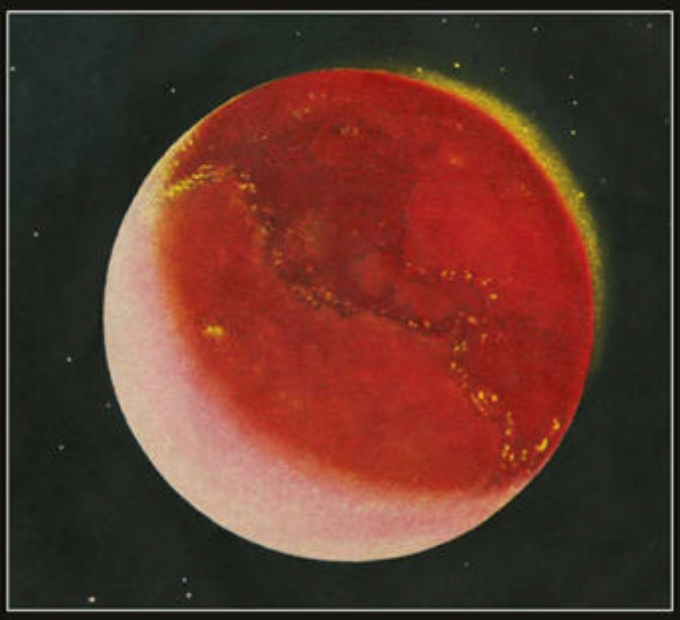
DEATH BY FREEZING ▷

***Coronet* caption:** Among the potential destroyers of our planet are the dark stars – those invisible cold masses whose presence is known only by their attraction for the other astronomical bodies, like the Earth. If a dark star should kidnap us from the Sun by pulling us out of our orbit, a loss of only a small percentage of the Sun's heat would freeze the Earth. Even a tropical Rio de Janeiro (right) would be buried under tonnes of ice. All life would perish in the cold, and it is unlikely that the Earth's heat would ever be restored.

We say: Were a wandering 'dark star' – presumably a black hole – to find its way among our planets, it would alter all of their orbits, not just Earth's. But depending on the direction of approach of the encroacher, Earth could be flung farther from the Sun, and indeed plunged into a deep freeze, or sent the other way to embrace a fiery doom. Either way, our planet's demise is assured. However, just as with the 'Battle of Gravity', the sparseness of space ensures that it is exceedingly unlikely that any massive objects will pass close enough to the Solar System to bring us any serious grief.

What are the chances?
Exceedingly unlikely; less than 0.1 per cent. ▸





◁ DEVASTATING SUNSHINE

***Coronet* caption:** Death from the Sun could strike tomorrow, for, like other stars, the Sun can at any moment become a nova, giving off a vast atmosphere of hot gas. By expanding, this gas would engulf us. It would then melt the Earth's crust, which is thought to average about 35 miles in thickness, turn our mountains into volcanoes, the rock beneath the Pacific Ocean (left) into live coals, and finally vaporise our planet, and possibly all the other planets in our Solar System, out of existence. Only the Sun would remain.

We say: The Sun cannot 'go nova' – though it is still a popular public misconception. We now know that a nova is an event involving two stars. One of them pulls gases from the other, which creates instability and eventually leads to a cataclysmic explosion. If the Sun could undergo a nova-like explosion, it probably would sterilise our planet and perhaps even melt its surface, but it certainly wouldn't vaporise it.

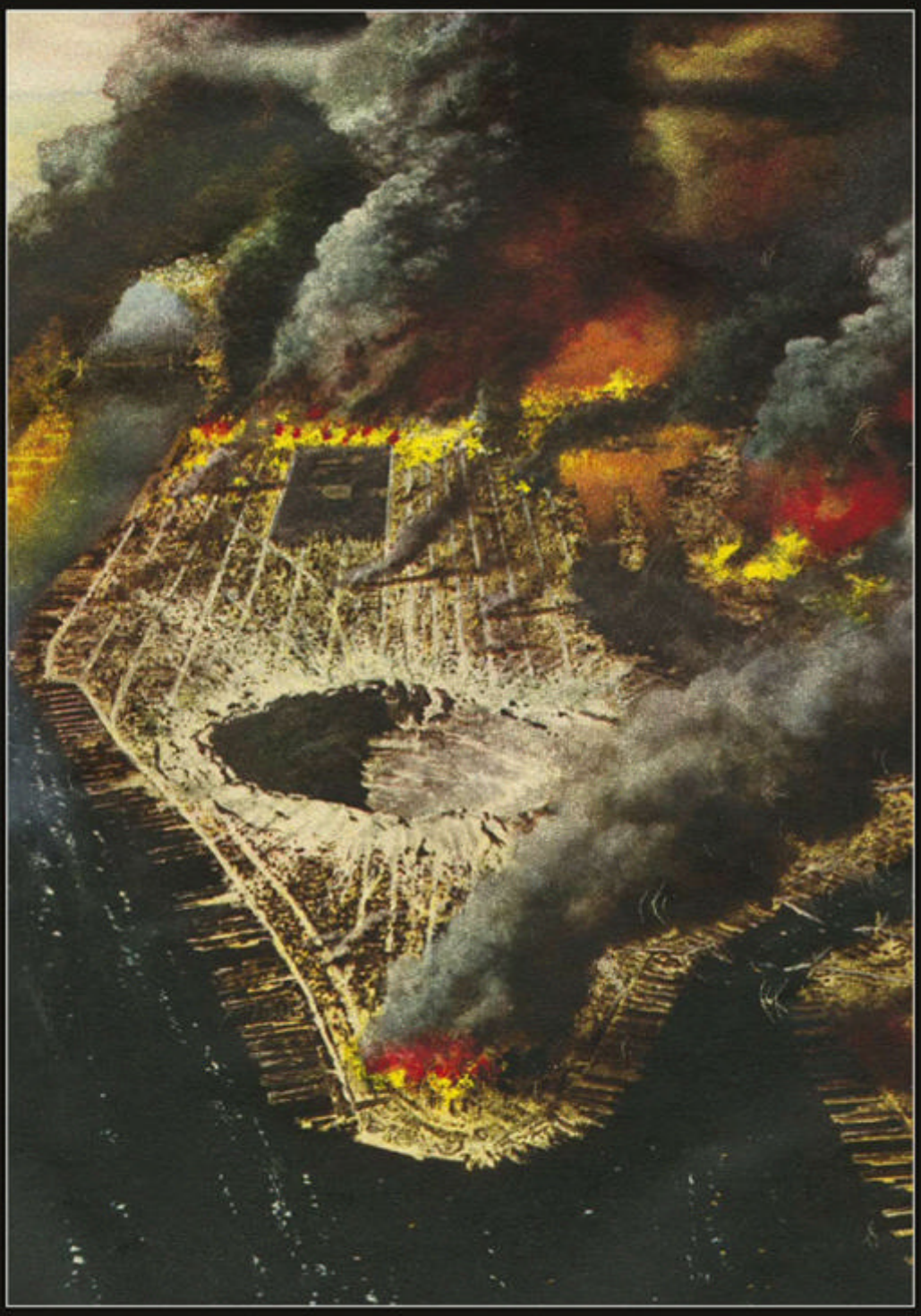
What are the chances?
It's not going to happen; 0 per cent.

DANGER FROM THE MOON ▷

***Coronet* caption:** The Moon's influence on our ocean tides retards Earth's rotation about one second every 100,000 years. As the Earth slows, the Moon is receding to a point where the Earth's rotation might accelerate and, like a colossal magnet, draw the Moon back to within 8,000 miles of us. Then, as the Moon is split apart by our superior force of gravity, its huge fragments will shatter our cities into oblivion. The fragments which did not hit us would remain to circle the Earth like millions of new moons.

We say: It is difficult to understand what the author describes in this scenario. There is no physical reason why Earth would suddenly start to spin up simply because it's getting further from the Moon's tidal influence. Calculations show that the rate of Earth's spin will gradually diminish over the course of tens of billions of years. Even if Earth did somehow spin up, this would not ramp up the dynamo-driven magnetic field to the extent that it would pull the Moon back towards us – and to an untimely destruction.

What are the chances?
It's not going to happen; 0 per cent.



◁ TARGET FOR METEORS

***Coronet* caption:** The Earth is never safe from meteors, which fly through space by the millions. In 1908, meteoric material fell in Siberia, and in prehistoric times a meteor tore a huge hole in Arizona. No one was hurt by those masses of hot metal, but here you see how a meteor could rip open New York City. After punching a mile-wide hole in the middle of Manhattan, it has set off tremendous explosions, killing millions and enveloping the city in flames. For New Yorkers this would be the end of the world.

We say: The asteroid/comet impact scenario is a very real and constant threat. Worse, the chances are that we would not spot such an impending fate until it was far too late to do anything about it, even if we had the technology in place. Earth has been struck countless times by comets and asteroids in the past – more than the Moon, and look at all the craters it has. It's just a matter of time before it happens again.

What are the chances?
With time, 100 per cent.

Our knowledge of the Universe we live in continues to grow. Indeed, in the near 70 years since *Coronet* published the original article we have become aware of another danger to our fragile world, and that is the possibility that a nearby star could explode as a supernova and sterilise Earth with its deadly fallout. There are hints this has happened before in our planet's history. Luckily, though, there are no candidate stars close enough to us that pose such a threat.

However, the impact of an asteroid or comet with the Earth is a very real menace. An event such as this is not just plausible – it's quite possible. But we can do something about it. With missions like Deep Impact and Rosetta, we have already proved that we can crash into and land on these small bodies; we now need the wide-field sky surveys to locate the asteroids that pose the greatest threat. We can only hope that the Universe gives us enough time.

ABOUT THE WRITER

Astrophysicist Mark Garlick is an illustrator and author. A member of the International Association of Astronomical Artists, his most recent book is *The Cosmic Menagerie*.

ABOUT THE ARTIST

Chelsey Bonestell (1888-1986) was an American space artist whose illustrations helped to popularise manned spaceflight. His work also included paintings for sci-fi films of the 1950s.

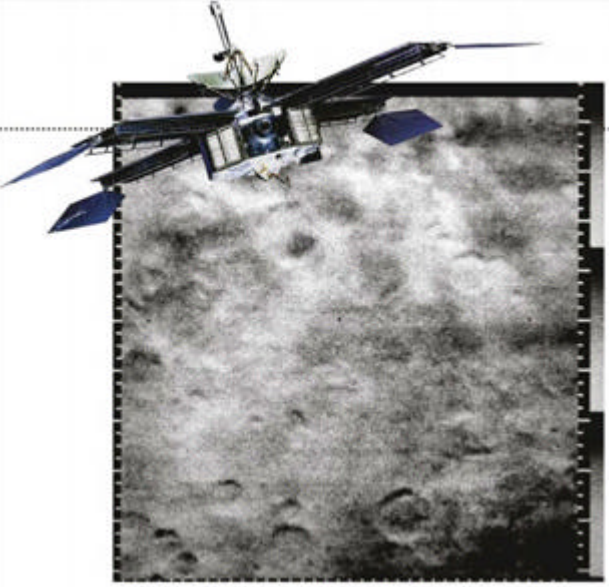
50 YEARS OF MARS EXPLORATION

On the 50th anniversary of Mariner 4's flyby of the Red Planet, **Will Gater** celebrates the top 10 greatest moments in the history of the robotic investigation of Mars

Fifty years ago this month NASA's Mariner 4 spacecraft made the first successful swoop past Mars. From the few grainy pictures that the pioneering probe returned to Earth, our knowledge and exploration of the Red Planet has flourished. Today scientists have a daily flow of high-resolution images – and invaluable scientific data – at their fingertips, sent back not only by an array of orbiters but surface-wandering rovers too.

These missions have painted a picture of an ochre world of towering mountains, vast ravines and swirling dust storms. But they've also shown us eerily familiar landscapes and revealed that Mars was very likely to have possessed large amounts of flowing water in the past. What then are the missions and scientific discoveries that have defined the past five decades of humankind's robotic exploration of the Red Planet? Read on for our pick of the 10 most thrilling, sometimes unexpected and occasionally downright heart-stopping moments at Mars.

Our rovers have travelled huge distances, leaving tracks like these in their wake; Opportunity has journeyed so far it has managed to complete a marathon



▲ 10. Mariner 4's flyby

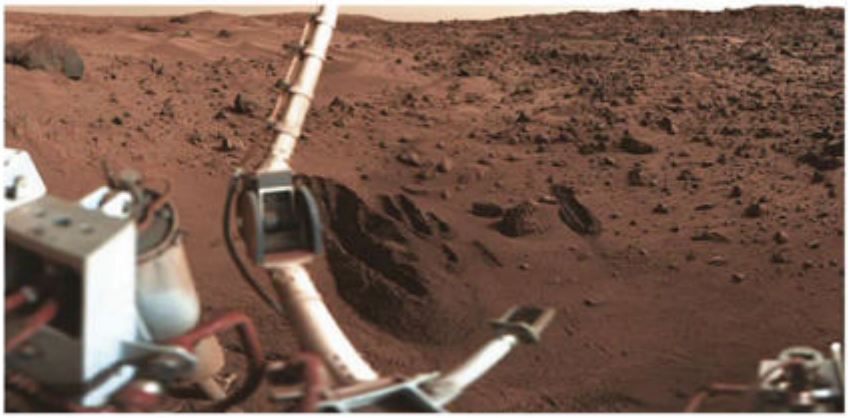
Date of flyby: 14 July 1965
Achievement: First flyby

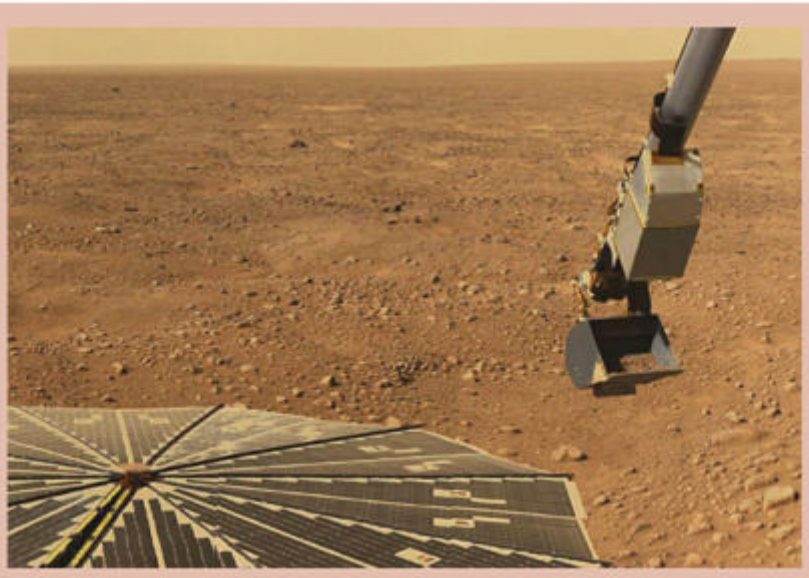
We kick off our top 10 with the mission that blazed the trail to the Red Planet. Although it didn't land on Mars, NASA's Mariner 4 mission sent back the very first close-range photographs of the planet. The probe was launched on 28 November 1964 and took seven and a half months to get to Mars. It began its historic first flyby on 14 July 1965 (closest approach came on the 15th) and sent back more than 20 black-and-white images, including the one above, revealing large craters, the limb of Mars and other detail to scientists waiting on Earth. Mariner 4 finally laid to rest the notion that the Red Planet was home to higher life forms, popularised by Percival Lowell's theory of Martian canals.

▼ 9. Viking 1 on the surface

Date landed: 20 July 1976
Achievement: First US landing

No mention of the greatest moments in Mars exploration would be complete without the Viking 1 mission. The lander element of the mission entered Mars's atmosphere on 20 July 1976 and, after using a parachute and powerful retrorockets to slow its descent, landed successfully in the Chryse Planitia region. The lander sent back captivating colour images from the surface, showing a ruddy landscape covered in numerous rocks and boulders. It also performed analyses of the Martian soil to see if life existed on the planet: these produced apparently negative results, but the experiments nevertheless remain a source of debate even today.





▲ 8. Phoenix explores the frozen north

Date landed: 25 May 2008
Achievement: Northernmost landing

Most of the missions that have explored Mars have landed in the regions roughly 30° either side of the planet's equator. But in May 2008, NASA's Phoenix lander explored new territory by touching down in the Red Planet's north polar region at a latitude of 68°N. The stationary platform captured images of the flat plains around it as well as clouds passing over its landing site. Phoenix was equipped with an extendable arm and scoop, which was used to reach out and retrieve samples of ice-rich soil for study. A camera on the arm even showed icy patches right beneath the lander itself, shown left.

▼ 7. Curiosity identifies organic molecules

Date announced: 16 December 2014
Achievement: Discovery of organic molecules in Martian rock

Of all the questions scientists have about Mars, the puzzle of whether the planet was ever hospitable to life is perhaps the most intriguing. In 2014, NASA's Mars Science Laboratory team announced that the rover's SAM (Sample Analysis at Mars) instrument had identified organic molecules in material extracted (via its drill) from a rock. Though the organic materials the rover uncovered are not necessarily an indication of life, it is thought that such substances are needed to make it. The finding marked an important moment in our understanding of the past habitability of Mars. ▸

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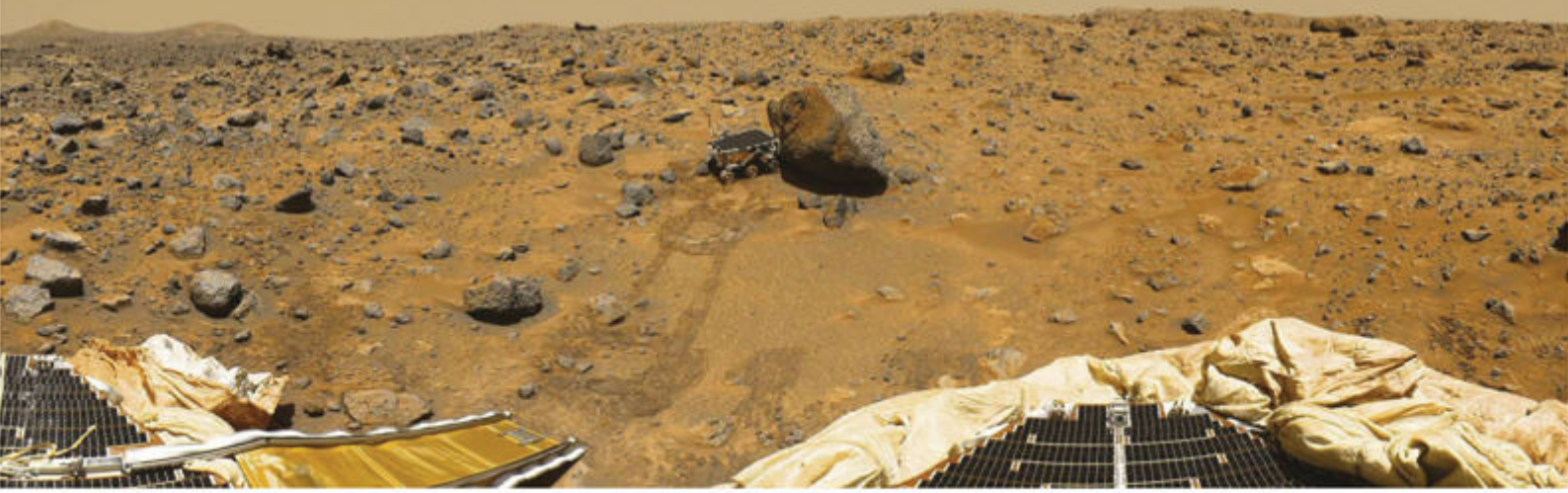
6. Sojourner's wanderings

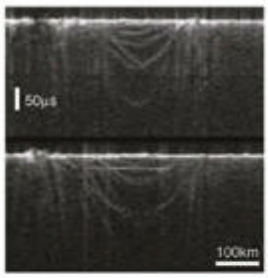
Date deployed: 5 July 1997
Achievement: First wheeled rover

Long before the Mars Exploration Rovers or Curiosity even got to the clean room, NASA's little Sojourner rover showed us just how useful a mobile explorer could be on the Martian surface. Sojourner was launched as part of the Mars Pathfinder mission, which landed in the Ares Vallis on 4 July 1997. Just 65cm long and powered by a small solar panel, the rover used six spiked wheels to move around. With the Mars Pathfinder acting as a base station, Sojourner was instructed to inch off a ramp on the lander and onto the Martian soil. From there it was sent to study nearby rocks – the image below is a 360° panorama from Sols 8-10 of the mission. Pictures of Sojourner investigating the boulders quickly became some of the most iconic planetary exploration shots of the 1990s. The mission also recorded measurements of wind speeds and temperatures using a 'weather station' on the lander.



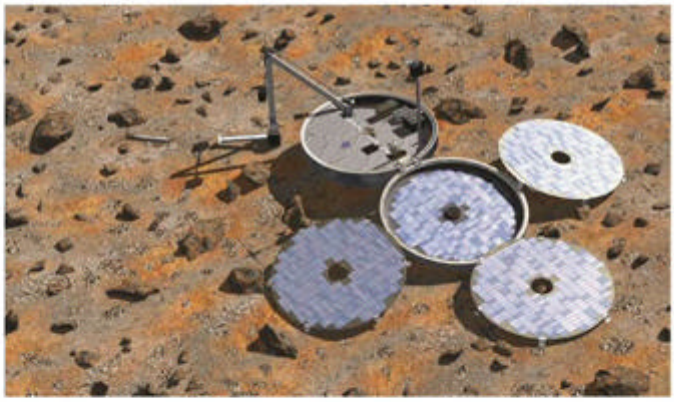
▼ 5. Mars Express sees subsurface features using radar mapping

Date into orbit: 25 December 2003
Achievement: Valuable radar mapping of planetary structure



While the surface of Mars has fascinated astronomers for decades, it's what lies under the dry and dusty soil that gets many planetary scientists excited. ESA's Mars Express spacecraft has been instrumental in showing that the Martian subsurface can be every bit as intriguing as what's above.

Alongside several other instruments – including spectrometers and a high-resolution colour camera – Mars Express is equipped with a powerful radar system, known as MARSIS. The instrument makes use of three large antennas, two of which are 20m long. By firing radio waves towards Mars and listening for their return, MARSIS is capable of exploring the hidden features that lurk far beneath the planet's ochre surface. 'Radargrams' such as the one above have helped to reveal enormous buried craters, some of which may contain water-ice, and in 2012 scientists using MARSIS announced they'd found suggestions of an ancient sedimentary seabed near Mars's north polar region.

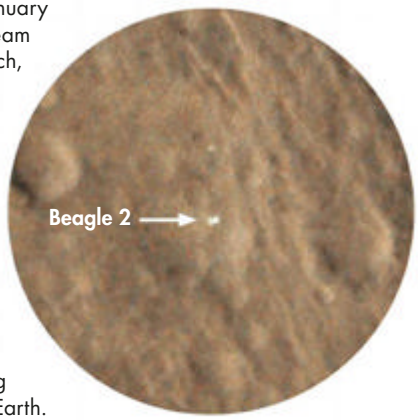


▲ 4. The loss and rediscovery of Beagle 2

Date deployed: 19 December 2003
Achievement: Compelling story of loss and discovery

On 19 December 2003 the UK's Beagle 2 probe left its mothership, ESA's Mars Express, and began its journey towards landing on the Red Planet. In the following days, however, there was no communication from the spacecraft on the surface. With apparently no sign of it on Mars in images taken from orbit, Beagle 2 was considered lost and many concluded that it had simply crashed. That was until earlier this year.

At a press conference on 16 January representatives from the mission team announced that, after a long search, they had finally found what they thought was the lander sitting on the surface. Not only that, but their study of imagery from NASA's Mars Reconnaissance Orbiter, shown right, suggested Beagle 2 had made it through the Martian atmosphere intact before landing successfully – a tremendous feat in itself. The probe's solar arrays had only partially opened, though, meaning that it couldn't communicate with Earth.



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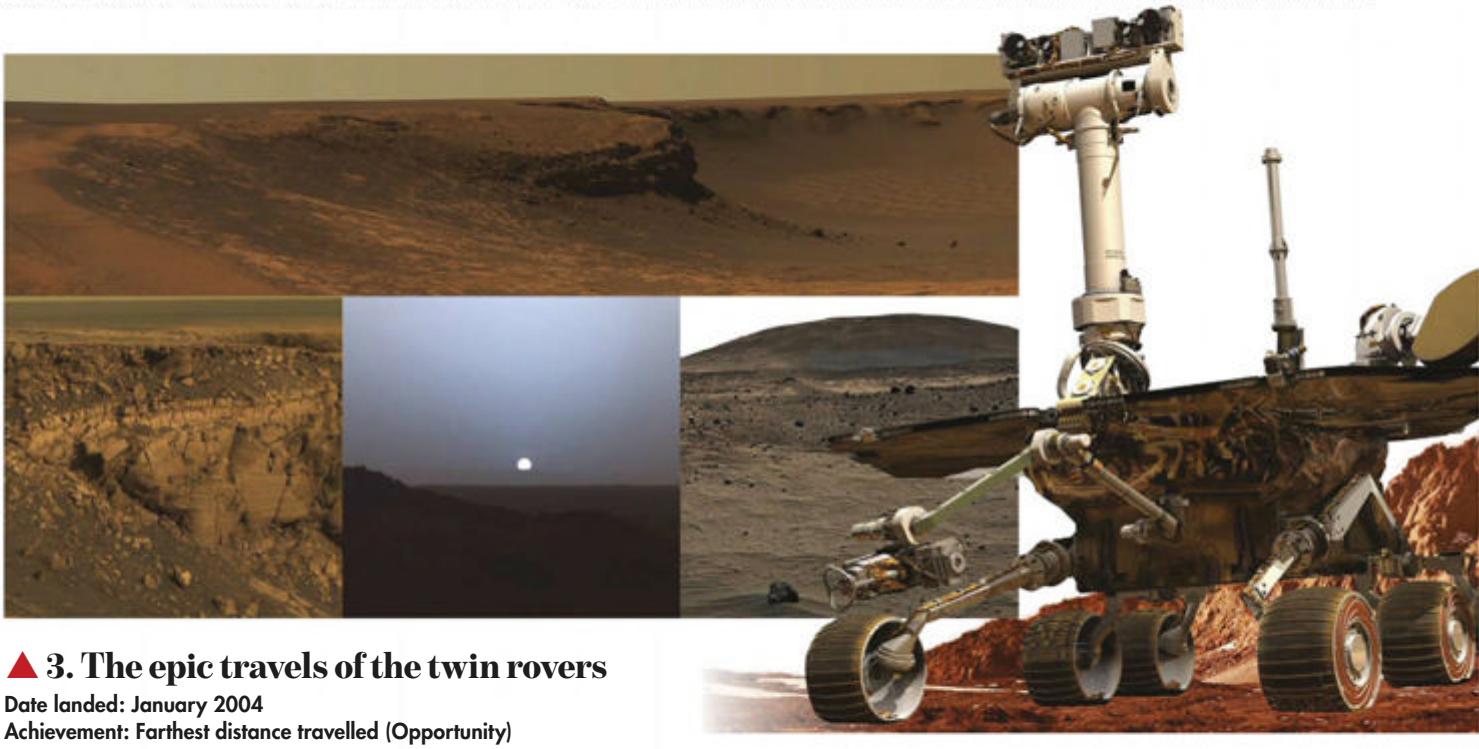


▲ 3. The epic travels of the twin rovers

Date landed: January 2004
Achievement: Farthest distance travelled (Opportunity)

Launched in June and July 2003, the twin Mars Exploration Rovers Spirit and Opportunity were tasked with investigating different sites – Spirit touched down in Gusev crater on 4 January 2004 while Opportunity arrived at Meridiani Planum on 25 January.

From the moment they rolled onto the Martian soil, the rovers' cameras brought the spectacular landscapes around them to life, as shown in the images above, just as Mars Pathfinder had done before. But while Mars Pathfinder's Sojourner rover only explored a small area of its immediate surroundings, the Mars Exploration Rovers have wandered far from their landing sites. Under the guidance of their controllers, they became true robotic explorers.

In the years following their arrival at Mars, Spirit and Opportunity made numerous important discoveries, and today their websites overflow with the stunning high-resolution images and panoramas they've returned. Among their many findings, the rovers have shown that water must have been present long ago at their landing sites.

For one of the rovers, however, trouble lay ahead. In May 2009 Spirit, shown top right, became trapped in soft, deep soil and, despite the best efforts of NASA, couldn't be freed. Spirit wasn't able to get enough sunlight on its solar panels over the following Martian winter and in May 2011 was declared lost. But Opportunity has continued on its epic trek. At the time of writing it has driven over 42km and its mission has now lasted an extraordinary 4,015 Martian days – 3,925 more than initially planned. With the Sun on its dusty solar panels and a steady stream of images and scientific data coming back to Earth, let's hope it can hold on for many more yet.

2. Mars Reconnaissance Orbiter watches a dynamic world

Date into orbit: 10 March 2006
Achievement: High-resolution imaging of the planetary surface

From its vantage point 255-320km above the surface, NASA's Mars Reconnaissance Orbiter (MRO) has imaged the Red Planet in extraordinary detail since its arrival in 2006. The spacecraft's powerful HiRISE (High Resolution Imaging Science Experiment) camera has spied boulder-strewn craters, enormous dunes and windswept plains scarred by cliffs and valleys. With its distinctive turquoise and brown colour palette – a quirk of the way the colour images are produced using the camera's wavelength filters – HiRISE has produced thousands of pictures which, at times, seem like works of art as much as scientific observations.

With the help of HiRISE, the Mars Reconnaissance Orbiter – perhaps more than any other Mars mission – has shown us just how dynamic the planet can be. It has captured images of fresh impact craters that were formed during its time at Mars, produced remarkable pictures of dust devils whirling across the arid landscape below, and has seen avalanches sending plumes of rocks and dust barrelling down cliff faces.

But it's also had more in its sights than just the dramatic scenery of Mars. In 2008 it took one of the most astonishing space pictures ever, showing NASA's Phoenix lander plummeting through the Martian atmosphere, its parachute billowing and straining behind. And it's even imaged the rovers on the surface, along with the thin, meandering tracks they've left behind in the ruddy soil. ▸

The MRO has witnessed dust rising as a result of Martian avalanches (main pic) as well as dust devils (bottom inset) and the descent of the Phoenix lander (top inset)

Anticlockwise from top: an artist's conception of Curiosity's sky-crane landing; Curiosity images its own heat shield as it descends; cheers in the control room on landing; and the rover's view after touchdown

NASA/JPL-CALTECH X 4

▲ 1. Curiosity's landing

Date landed: 6 August 2012
Achievement: Epic and audacious landing profile successfully delivers largest wheeled rover yet

For those watching NASA Television on the morning of 6 August 2012, our top moment in the history of robotic Mars exploration will come as no surprise. The landing of NASA's Mars Science Laboratory – the Curiosity rover – surely earns its place here with ease, not only for the way it had us all on tenterhooks but also for the immense ambition that those tense minutes represented.

Curiosity was launched on top of an Atlas V rocket on 26 November 2011. It had been designed to be the most advanced rover ever to roam Mars – a travelling extraterrestrial laboratory packed with scientific instruments and high-resolution cameras. With its advanced suite of instruments, scientists hoped the rover would be able to tell us about the past and present conditions on the Red Planet: it would assess in detail the geological make-up of a specially chosen landing site, the 154km-wide Gale crater, with the aim of finding out if life could have once existed there. And it would also sniff the Martian atmosphere and look for signs of the ancient processes that shaped t he barren, alien landscape.

Curiosity was big too, measuring 3m long and weighing 899kg. To get such a heavy craft down to the surface required something more than the airbags and retrorockets employed by her predecessors. NASA had the answer – it was called the 'sky crane'. Once the rover was safely through Mars's atmosphere it would release its heat shield, parachute and another cover known as the 'back shell'. From then on it would be cradled by the sky crane. Around 1.6km above the ground, powerful rockets on the device would roar into life to slow the descent. As it neared the surface, strong tethers would lower Curiosity beneath the now hovering rocket-powered platform, gently placing the dangling rover onto the Martian soil. It was a plan that put most science-fiction stories to shame. NASA dubbed it the 'seven minutes of terror'.

It was for this reason that thousands of space enthusiasts watched with bated breath that August day as the incredible drama played out. With all eyes fixed on the banks of black desks and the blue-shirted mission team behind them, the crucial signal came down: the sky crane had worked and Curiosity was sitting safely on Mars. Around the world, as mission control erupted into jubilant cheers and hugs, a tear or two were shed – a new chapter of Martian exploration had begun.

ABOUT THE WRITER
Will Gater (@willgater) is an astronomer and writer. He is the author of several books and presents live astronomy shows for Slooh.

The Sky Guide July

Venus has been gracing our western skies after sunset for several months. Through a telescope its phase is now a slender crescent. However, the position of Venus is worsening after sunset, so to see it best you'll need to look in daylight.

Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

PETE LAWRENCE

Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity

1 WEDNESDAY
Venus and Jupiter are approximately 0.5° apart this evening, visible low in the west-northwest shortly after sunset. To the naked eye, the planets will look like a mismatched double star.

2 THURSDAY
The first full Moon of the month occurs today. This is a great time to look out for the Moon illusion because the fuller phases occur when the Moon's low in the sky during the summer months. The Moon illusion makes the Moon artificially look much larger than it actually is.

3 FRIDAY
The mag. +9.5 minor planet Pallas passes just to the south of mag. +3.1 Sarin (Delta (δ) Herculis) tonight. Pallas curves southwest throughout the rest of the month. See page 47.

5 SUNDAY
Comet C/2014 Q1 PanSTARRS should be around maximum brightness at the moment but a tricky find in the dawn twilight before sunrise. See page 47.

6 MONDAY
Dwarf planet Pluto comes to opposition today. It is in Sagittarius, on the lip of the bowl of the Teaspoon asterism. See page 47.

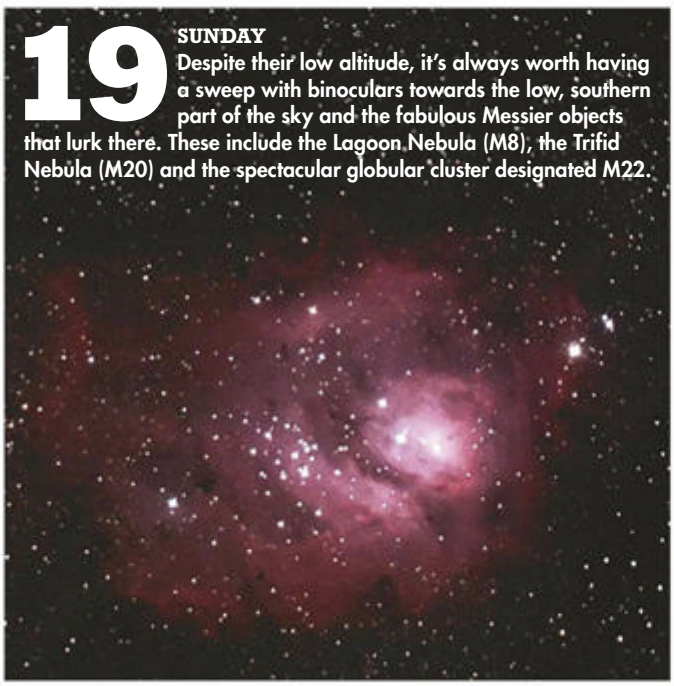
Earth is at aphelion and farthest from the Sun in its orbit at 20:41 BST (19:41 UT).

14 TUESDAY
A 4%-lit waning crescent Moon lies 13° to the west (right) of mag. –1.2 Mercury this morning. Look for both objects low in the northeast from about 04:10 BST (03:10 UT) until shortly before sunrise.

15 WEDNESDAY ▶
A must see sight for summer is the spectacular binary star Albireo (Beta (β) Cygni). Through a telescope the yellow primary and blue secondary are quite breathtaking. Even if you've seen them before, it's worth taking a moment to revisit them.

16 THURSDAY
A very tricky close encounter between Mars and Mercury occurs this morning, with Mars just 9 arcminutes to the north of Mercury. The planets will be low in the northeast just before sunrise. Mercury is mag. –1.4 and Mars a fainter mag. +1.6.

19 SUNDAY
Despite their low altitude, it's always worth having a sweep with binoculars towards the low, southern part of the sky and the fabulous Messier objects that lurk there. These include the Lagoon Nebula (M8), the Trifid Nebula (M20) and the spectacular globular cluster designated M22.



PETE LAWRENCE X 7

25 SATURDAY
Ceres is at opposition. The mag. +7.5 dwarf planet is on the border of Microscopium and Sagittarius, which means it's quite low from the UK. The best way to spot it is to image or sketch the area it will be in over several nights to see it move. See page 47.

26 SUNDAY
As the sky darkens look out for the 76%-lit waxing gibbous Moon towards the southern part of the sky. The brighter dot to its right is mag. +0.7 Saturn; the one below is mag. +1.0 Antares (Alpha (α) Scorpii)

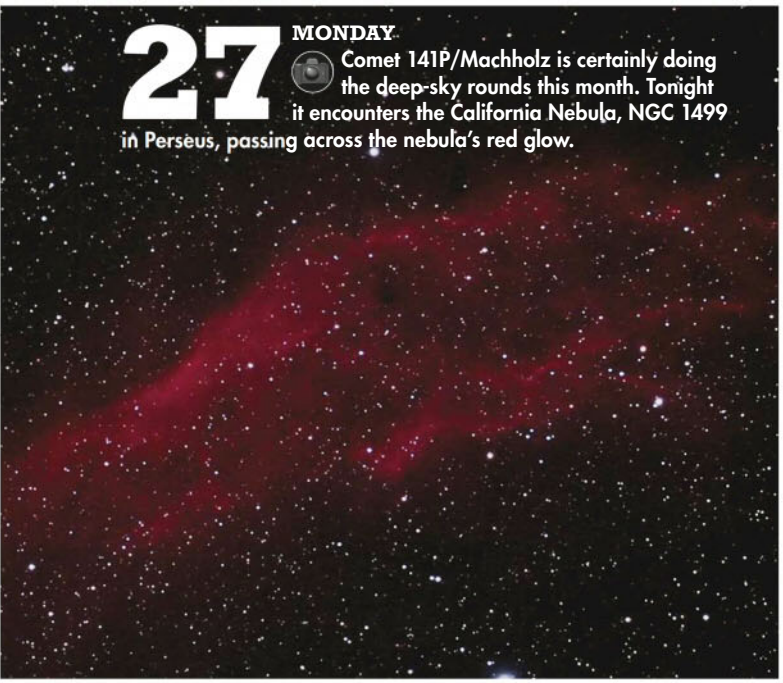
31 FRIDAY ▶
The second full Moon of July 2015 occurs today. A modern term for the second full Moon in a single month is to call it a 'blue Moon', although the origins of this originally stem from a publication mistake.

4 SATURDAY
Noctilucent cloud season continues throughout July. Look out for these eerie blue clouds shining approximately 90-120 minutes after sunset low in the northwest and a similar time before sunrise low in the northeast.

9 THURSDAY ▶
Comet 141P/Machholz crosses M33, shown on the right, through tonight and tomorrow night. The crossing is visible very low in the northeast after midnight.

17 FRIDAY
The Summer Triangle asterism is high in the southern part of the sky around midnight. If you have dark skies, look out for the fabulous Milky Way running down through the triangle towards the southern horizon.

18 SATURDAY
The Moon's now out of the way and the nights are getting slightly darker. This is a great time to try out our deep sky tour – see page 52.



27 MONDAY
Comet 141P/Machholz is certainly doing the deep-sky rounds this month. Tonight it encounters the California Nebula, NGC 1499 in Perseus, passing across the nebula's red glow.

What the team will be observing in July

Pete Lawrence "I'll be looking for comet C/2014 Q1 PanSTARRS in the early morning sky at the start of July. It will be a balancing act between twilight brightness, comet brightness and comet position. The fun is in the chase!"

Paul Money "I'll be aiming to see the close pairing of Venus and Jupiter on the first of the month before they drop lower into the bright evening summer twilight and encounter Regulus on the 18th."

Steve Marsh "I've been waiting for an opportunity to take some atmospheric shots of a full Moon rising. With two of them this month, this is the time to do it!"

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

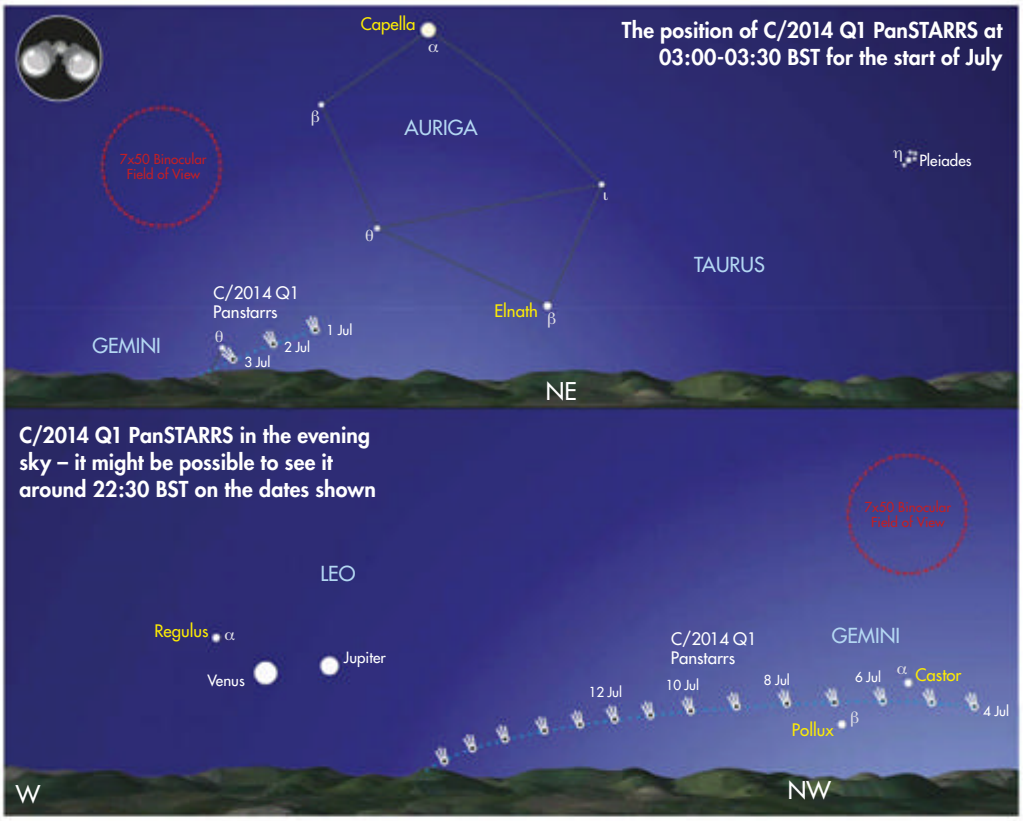
Getting started in astronomy

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

DON'T MISS... 3 top sights

A pair of July comets

WHEN: As specified



THE EARLY JULY mornings are full of promise this year, for as the night slowly draws to an end, there's a possibility that a naked-eye comet may be on view. Now, as is typical with comets, the timing isn't perfect, and the brightening twilight and low altitude will be an issue. Even so, a bright comet is always rather exciting.

In this case, the comet is C/2014 Q1 PanSTARRS, which reaches perihelion on 6 July. Perihelion is the point when the comet's orbit takes it closest to the Sun and the point when the comet's nucleus is quite vulnerable, as the thermal shock can sometimes lead to large outbursts of gas and dust, so causing the comet to brighten. At the start of July it'll be a 4th-magnitude evening object approximately 5° east of mag. +3.6 Theta (θ) Geminorum.

This is a very tricky location, the brightening dawn twilight sky and low altitude making a flat north-northeast horizon essential. It will be hard to see at this time but, as with all potentially bright comets, it's still worth having a look. Scan close to the northeast to north-northeast portion of the horizon from around 03:00-03:30 BST (02:00-02:30 UT). Stop if the sky gets noticeably bright because sunrise will be on its way.

The comet passes south of mag. +1.9 Castor (Alpha (α) Geminorum) on 6 July and north of mag. +1.2 Pollux (Beta (β) Geminorum) on 8 July. As it does so it'll be an evening object but again, very close to the Sun. It's predicted to reach mag. +3.5 at this time, which would make it an easy binocular object, although the bright twilight sky will do its best to hide it from view.

On these dates, the best strategy is to first locate Venus and Jupiter shortly after sunset. They will be very close low in the west-northwest. Using binoculars, scan to the right to locate Castor and Pollux. They will be extremely low down in the northwest, so a flat horizon in this direction will be essential. Once found, use our chart to see if you spot C/2014 Q1 PanSTARRS.

Another less bright comet, 141P/Machholz, will be in a more favourable position. This is a fainter telescopic object, starting the month at mag. +13.3 but brightening to +9.5 by the 31st. On 9 and 10 July, 141P/Machholz passes in front of M33 in Triagulum and on 26-28 July it crosses the California Nebula, NGC 1499 in Perseus. Both crossings should be visible, using a telescope, in the east and northeast part of the sky during the early hours.

NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.

Comet 141P/Machholz through July; positions correct for 01:00 BST

PETE LAWRENCE X4

Pluto at opposition

WHEN: From mid-month until 23 July

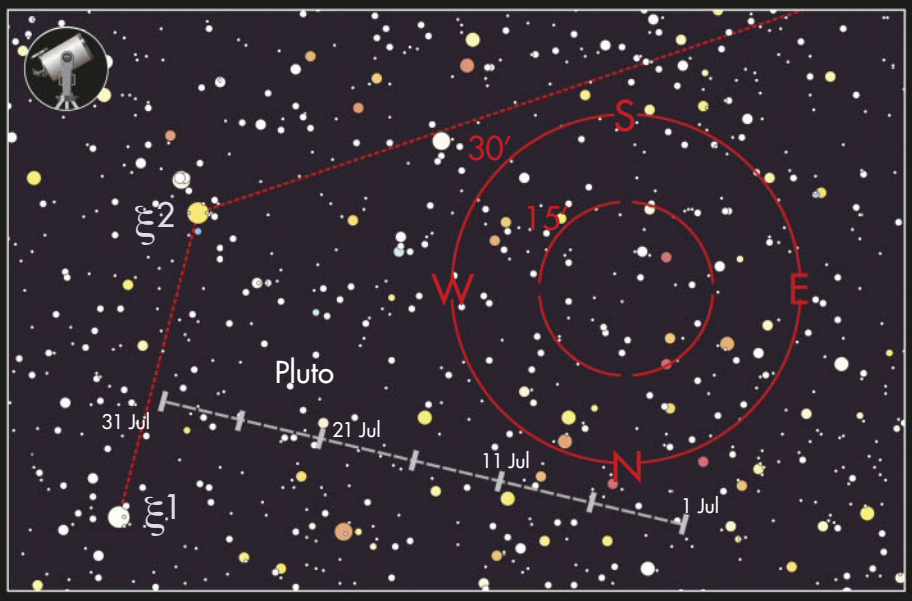
PLUTO COMES TO opposition on 6 July, a week before the New Horizons spacecraft performs its historic close pass of the dwarf planet. At present, mag. +14.1 Pluto is located in a small asterism in Sagittarius known as the Teaspoon, a companion pattern to the more famous and recognisable Teapot.

The Teaspoon is formed by a group of faint stars off to the northeast of the Teapot. The bowl of the teaspoon is formed from mag. +2.9 Pi (π), mag. +3.8 Omicron (ο) and mag. +3.5 Xi² (ξ²) Sagittarii. Located 0.5° above this last star is mag. +5.0 Xi¹ (ξ¹) Sagittarii, and these two stars provide the location anchor for Pluto.

At the start of July Pluto's faint dot forms the pointed top of an isosceles triangle with Xi¹ and Xi²; the point being located to the east of the stars. The dwarf planet then heads west, passing between both stars at the start of August. A shot of the Teaspoon's bowl taken with a DSLR or CCD camera fixed to a telescope should reveal Pluto after a relatively modest exposure and high sensitivity setting. Take several shots over subsequent days and you should be able to show the relative movement of Pluto throughout July.

The bright summer sky and Moon will conspire to hide Pluto from view. Our recommendation is to attempt to locate it around the middle of the month. Typically, the Moon starts to interfere from about the 23rd onwards, just as the night sky starts to get properly dark again.

A 12-inch telescope is recommended to see Pluto convincingly but reports exist of it having been seen in much smaller scopes. Success depends on how well adjusted your eyes are to the dark and how dark your skies are in this low area of the sky.



Pluto heads towards a finish line between Xi¹ and Xi² Sagittarii; stars shown to mag. +14.0

Ceres and Pallas

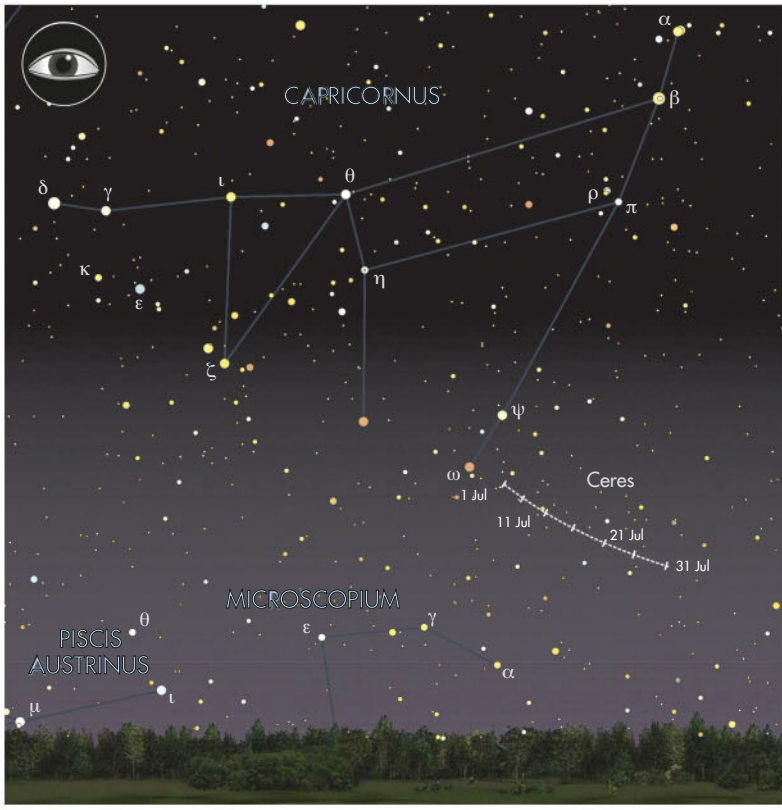
WHEN: Mid-month

DWARF PLANET CERES is at opposition on 25 July. At the start of the month, mag. +7.8 Ceres sits very close to mag. +4.1 Omega (ω) Capricorni, the star that marks the southern tip of the misshapen triangular pattern of Capricornus.

Ceres is technically in the constellation of Microscopium at this time and remains so until right up to the end of the month, when it just slips into Sagittarius. Its brightness rises slightly to around mag. +7.5 by the middle of the month, coinciding nicely with the absence of the Moon. Binoculars should show its dot fairly easily despite its low UK altitude.

If you struggle to spot Ceres, there's an easier target in the sky in the form of 9th-magnitude minor planet Pallas. Although fainter than Ceres, Pallas will be higher, which makes it more accessible. On 1 July it sits very close to the mag. +3.1 Sarin (Delta (δ) Herculis). It then passes even closer to the star, missing it by around 8 arcminutes on 3 July, before heading further to the southwest.

By the end of the month, the brightness of Pallas will have faded slightly to around +9.8, but its location keeps it high in the sky and out of the atmospheric haze which will make Ceres more difficult to spot despite being brighter.



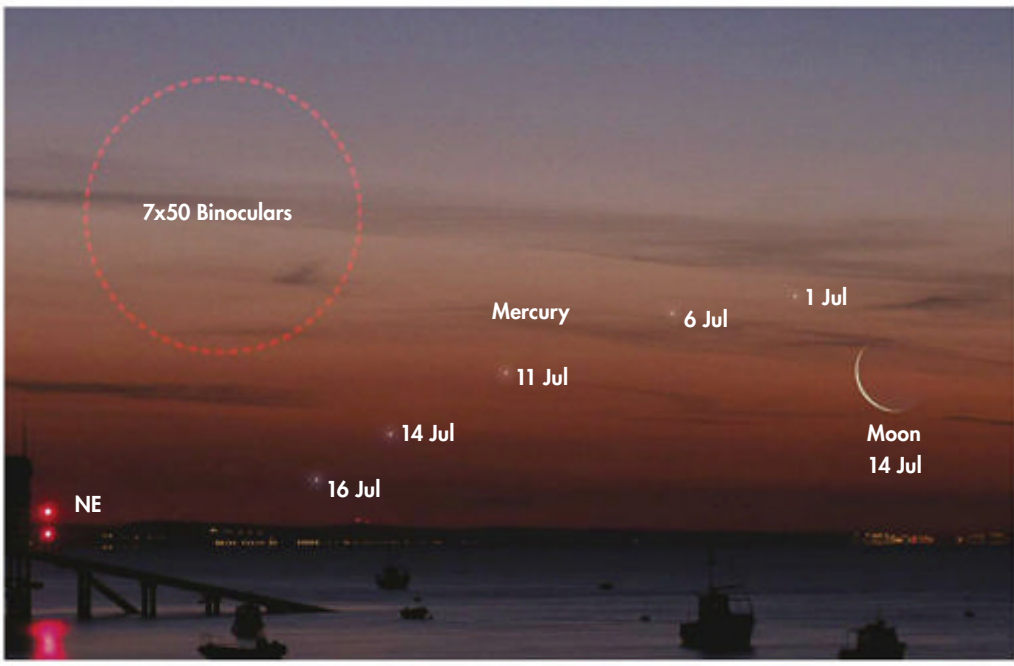
Ceres is quite close to Omega Capricorni at the start of the month

The planets

PICK OF THE MONTH

MERCURY

BEST TIME TO SEE:
7 July 04:00 BST (03:00 UT)
ALTITUDE: 3° (low)
LOCATION: Taurus
DIRECTION: Northeast
RECOMMENDED EQUIPMENT:
7x50 binoculars
FEATURES OF INTEREST:
Subtle marking through larger scopes, phase



Mercury's position in July at 04:30 BST; the Moon's size has been exaggerated for clarity

MERCURY IS A morning object for most of July. On the 1st, it rises above the northeast horizon at around the same time as Aldebaran in Taurus, about 03:40 BST (02:40 UT). The planet will be at mag. 0.0 on this date. Sunrise is just over one hour after Mercury first pops up above the horizon.

Over the following mornings, the planet will slowly brighten. Although this should make it easier to spot, it's offset by the fact that Mercury's apparent distance from the Sun is also decreasing.

On 5 July, Mercury's brightness will have increased to mag. –0.4, the planet now just 1.3° to the northwest of the mag. +3.0 Zeta (ζ) Tauri, and coincidently just 0.5° to the west of the Crab Nebula, M1 – although the nebula will be lost in the dawn twilight.

By 14 July, Mercury will have brightened to mag. –1.2 and despite closing in on the Sun, will have shifted into a position of higher declination, which still allows it to rise an hour before sunrise. On the morning of the 14th, look out for a slender 4%-lit waning crescent Moon, 13° to the right of the planet. On the 16th, mag. –1.4 Mercury passes a dimmer, mag. +1.6 Mars by just 9 arcminutes.

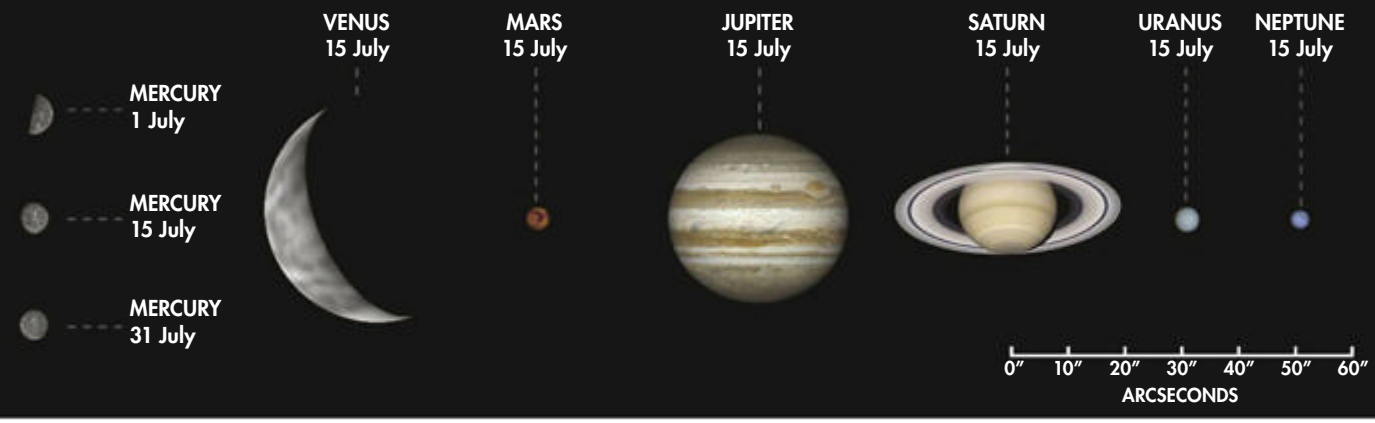
Mercury is moving away from Earth throughout most of July and so shows an increasing phase, growing from 52% lit on the 1st to 88% lit on the 14th. Its apparent size decreases over this period from 6 arcseconds to 5 arcseconds.

Superior conjunction occurs on the 23rd, when Mercury lines up with the Sun on the far side of its orbit. After this you might be able to catch a brief glimpse of it low in the west-northwest after sunset, when it'll be shining at mag. –1.1.

PETE LAWRENCE X 3

THE PLANETS IN JULY

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



VENUS

BEST TIME TO SEE: 1 July 22:00 BST (21:00 UT)
ALTITUDE: 13°
LOCATION: Leo
DIRECTION: West

Venus sets two hours after the Sun at the start of the month. At this time it'll be 0.5° from mag. –1.8 Jupiter; Venus will be mag. –4.4, easily outshining the larger planet. On the 9th, Venus is part of a flattened isosceles triangle with Jupiter and mag. +1.4 Regulus (Alpha (a) Leonis). Just over a week later, a 7%-lit waxing crescent Moon joins the scene, lying 2.5° west of Venus. Telescopically, Venus is an advanced crescent during July. It starts the month at 34%-lit and 32 arcseconds across, but this changes rapidly and by the 31st it will appear 0.1% lit and 51 arcseconds across. At month end, Venus's position in the evening twilight will have deteriorated so much that the planet sets just 10 minutes after the Sun.

SATURN

BEST TIME TO SEE: 1 July 23:00 BST (22:00 UT)
ALTITUDE: 18°
LOCATION: Libra
DIRECTION: South

Saturn is in a low southern part of the sky, close to the claws of Scorpius. The mag. +0.3 planet shows a 24° tilt, which tips its ring system towards us, giving a good view of the northern face of the rings. Saturn starts to lose what limited altitude it manages to attain as the sky starts to darken through July, but is still worth a look with a scope if you have a flat south-southwest horizon. A 66%-lit waxing gibbous Moon lies 6° east of Saturn on the 25th, increasing to 78% lit on the 26th, when it will be 7° to the east.

JUPITER

BEST TIME TO SEE: 1 July 22:00 BST (21:00 UT)
ALTITUDE: 13°
LOCATION: Leo
DIRECTION: West

Jupiter is now twilight challenged, a poor position for serious observation. On 1 July, it will be mag. –1.8 and 0.5° from Venus; Venus will be mag. –4.4, so together they will look like a bright but mismatched double star. On the 18th, together with a 7%-lit waxing crescent Moon and Venus, Jupiter forms a low triangle in the evening twilight.

NEPTUNE

BEST TIME TO SEE: 31 July 3:00 BST (02:00 UT)
ALTITUDE: 28°
LOCATION: Aquarius
DIRECTION: South

Mag. +7.8 Neptune is becoming better placed and reaches its highest point in the sky, due south, in darkness by the end of the month. Through a scope its 2.2-arcsecond disc doesn't give up any features, but it's still impressive to see its blue colour.

URANUS

BEST TIME TO SEE: 31 July 3:00 BST (02:00 UT)
ALTITUDE: 33°
LOCATION: Pisces
DIRECTION: Southeast

Uranus is slowly moving into a better position throughout July, but fails to reach its highest point in the sky, due south, before dawn. The mag. +5.8 planet is close to mag. +5.2 star Zeta (ζ) Piscium; on the 9th, a 47%-lit waning crescent Moon lies slightly less than 2° to the south.

MARS

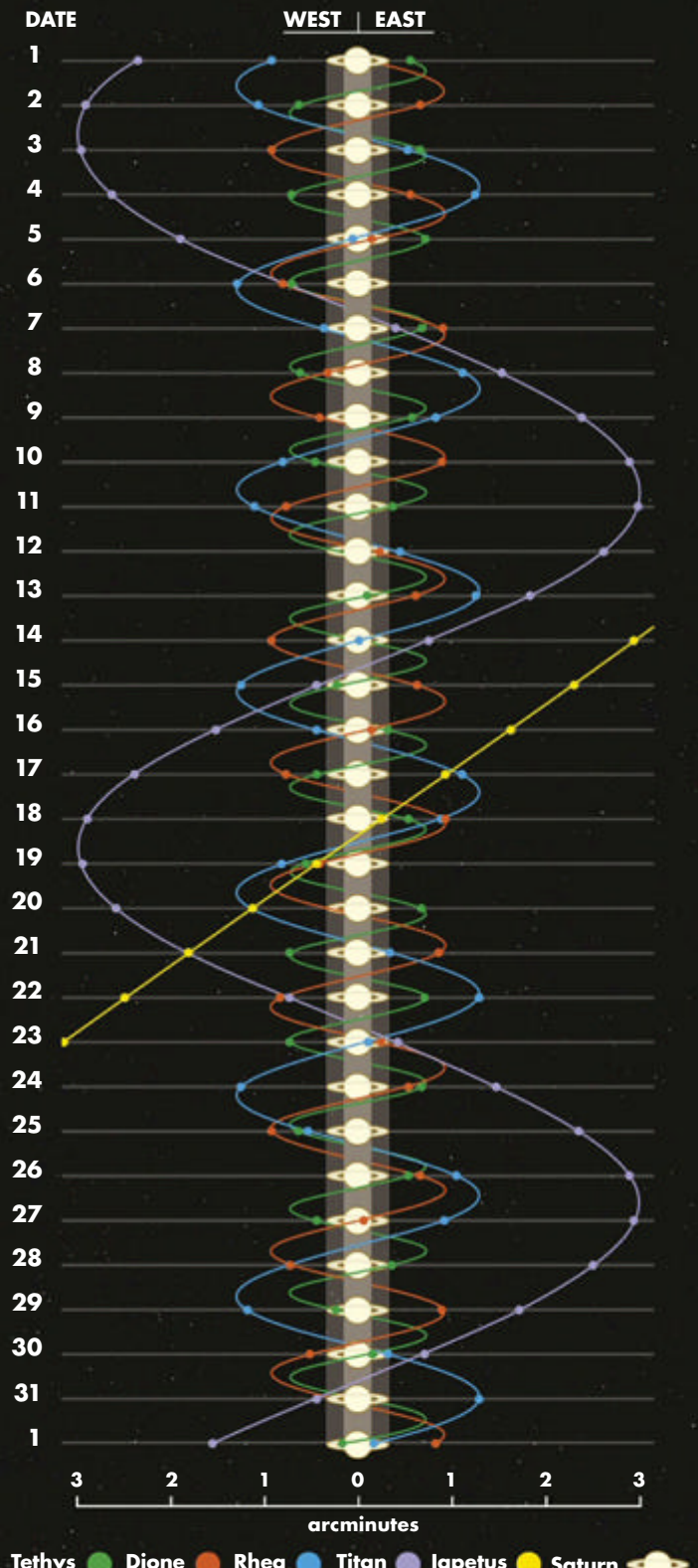
BEST TIME TO SEE: 31 July 04:30 BST (03:30 UT)
ALTITUDE: 2° (low)
LOCATION: Gemini
DIRECTION: Northeast

Mars is a morning object but is poorly located for general viewing. Its one notable encounter is on the 16th, when mag. +1.6 Mars and mag. –1.4 Mercury will be just 9 arcminutes apart.

See what the planets look like through your telescope with the **field of view calculator** on our website at:
http://www.skyatnightmagazine.com/astronomy-tools

SATURN'S MOONS
July

Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

- *Arcturus* — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

WHEN TO USE THIS CHART

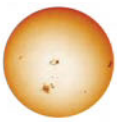
1 JULY AT 01:00 BST
15 JULY AT 00:00 BST
31 JULY AT 23:00 BST

On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

THE SUN IN JULY*



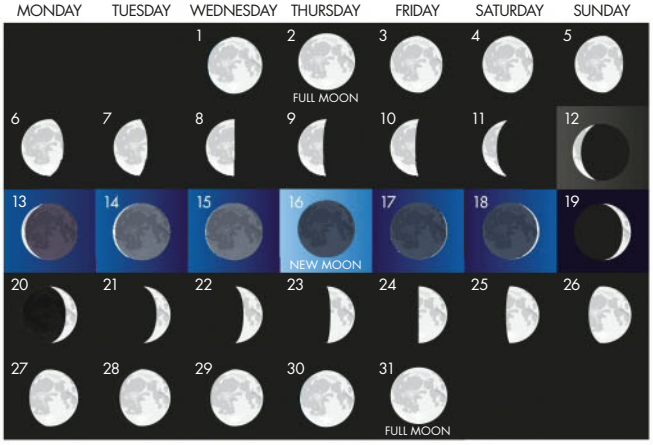
DATE	SUNRISE	SUNSET
1 Jul 2015	04:45 BST	21:41 BST
11 Jul 2015	04:54 BST	21:35 BST
21 Jul 2015	05:08 BST	21:23 BST
31 Jul 2015	05:23 BST	21:08 BST

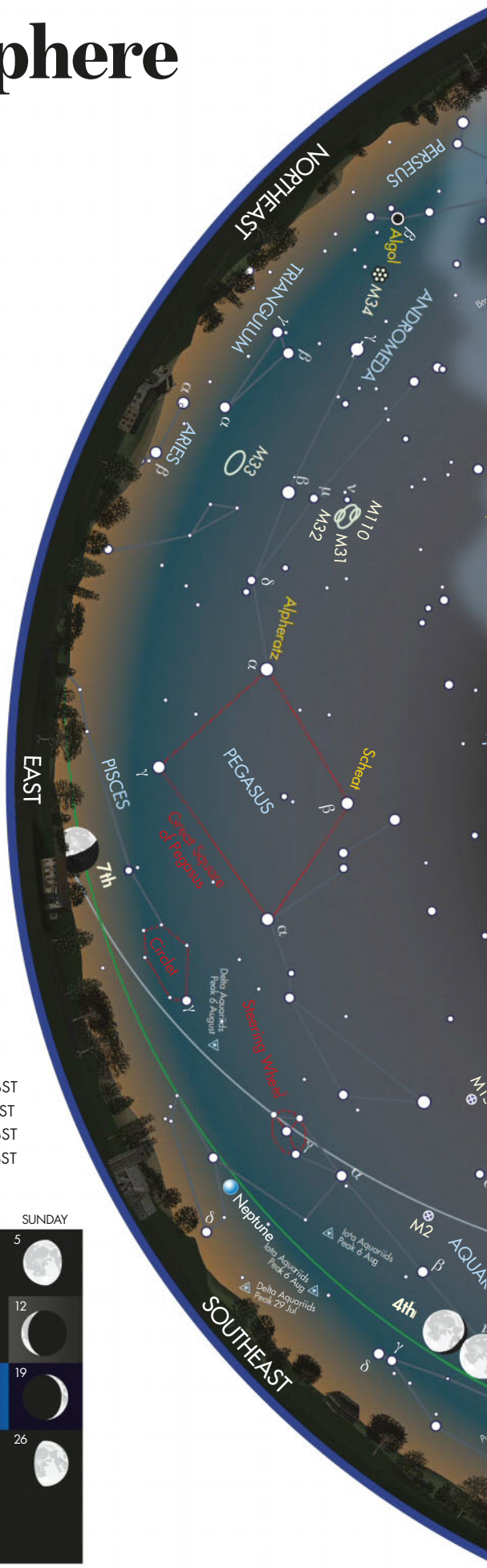
THE MOON IN JULY*

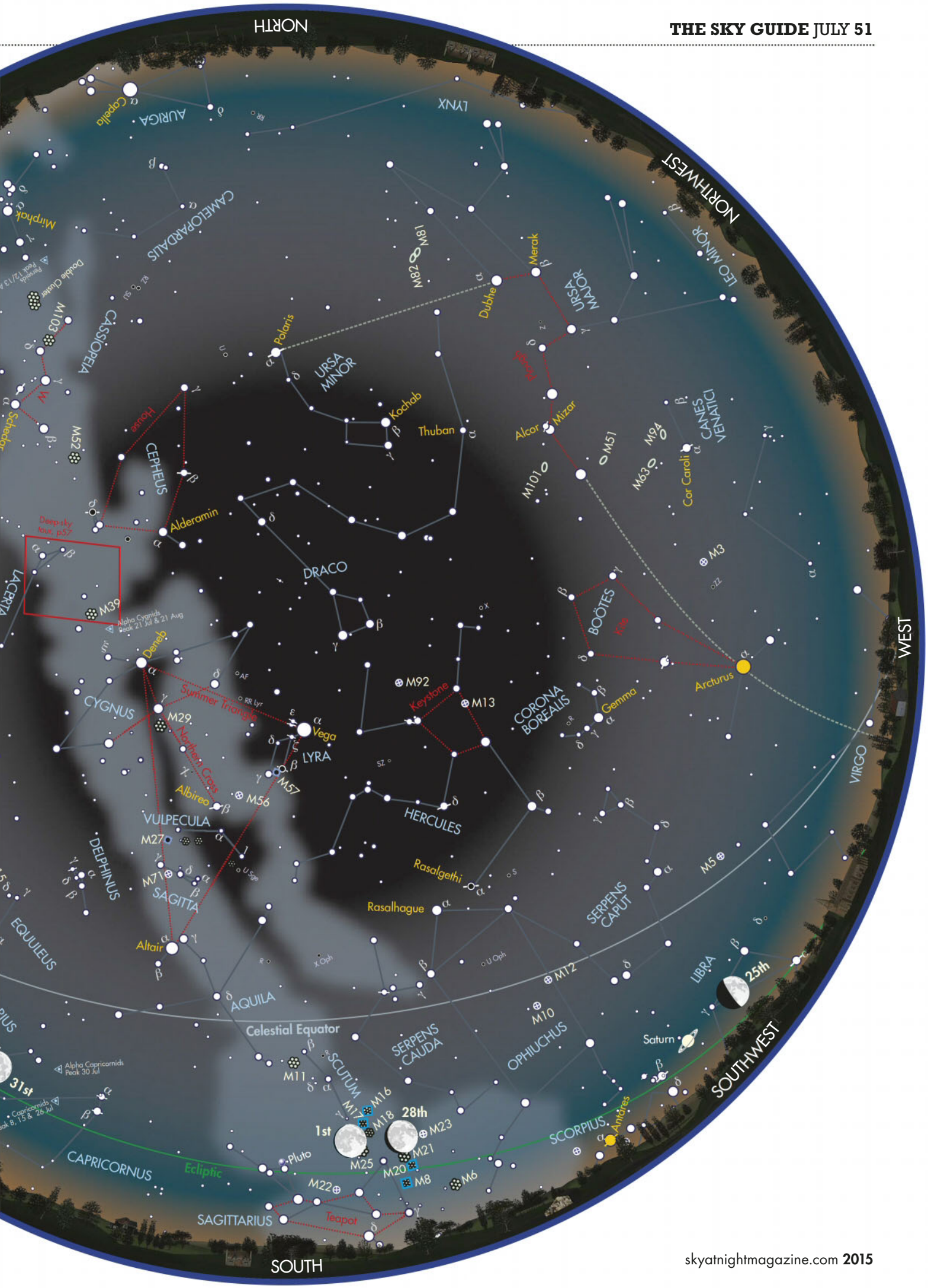
MOONRISE TIMES

1 Jul 2015, 20:44 BST	17 Jul 2015, 06:49 BST
5 Jul 2015, 23:20 BST	21 Jul 2015, 11:07 BST
9 Jul 2015, 00:41 BST	25 Jul 2015, 15:24 BST
13 Jul 2015, 03:00 BST	29 Jul 2015, 19:22 BST

*Times correct for the centre of the UK






NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Capella
AURIGA
LYNX
CAMELOPARDALIS
LEO MINOR
Mirfak
Double Cluster
M103
CASSIOPEIA
M82
M81
Merak
Dubhe
URSA MAJOR
Polaris
URSA MINOR
Kochab
Thuban
Alcor
Mizar
M51
M94
M63
M101
CANES VENATICI
Cor Caroli
CEPHEUS
Alderamin
M52
DRACO
Deep-sky tour, p57
LACERTA
M39
Alpha Cygnids Peak 21 Jul & 21 Aug
Deneb
CYGNUS
Summer Triangle
Northern Cross
M29
Albireo
M56
M57
Vega
LYRA
M92
Keystone
M13
CORONA BOREALIS
Gemma
BOÖTES
Kids
Arcturus
M3
VIRGO
VULPECULA
M27
M71
SAGITTA
DELPHINUS
HERCULES
Rasalgethi
Rasalhague
SERPENS CAPUT
M5
M12
EQUULEUS
Altair
AQUILA
LIBRA
25th
Celestial Equator
SERPENS CAUDA
OPHIUCHUS
M10
Saturn
Alpha Capricornids Peak 30 Jul
31st
M11
SCUTUM
M16
M17
M18
28th
1st
M23
M21
M25
M20
M8
M6
SCORPIUS
Antares
CAPRICORNUS
Ecliptic
Pluto
M22
SAGITTARIUS
Teapot

Deep-sky tour

We show you how to use a miniature Cassiopeia to find the delights of Lacerta

☑ Tick the box when you've seen each one

Open cluster NGC 7209 sits adjacent to a 6th-magnitude orange star

1 NGC 7243

Lacerta is a small, faint constellation located south of Cepheus and northeast of Cygnus. Visually it's not much to write home about, but it does contain a core asterism that looks like a small Cassiopeia – a Mini-W – and this is the best way to identify it. Mag. +6.4 open cluster NGC 7243 lies approximately 1.5° to the west of the central star of this Mini-W. Through a 6-inch scope this is a rich cluster, containing around 40 member stars arranged in a broken outer ring surrounding the cluster's core. A 10-inch scope reveals about 80 stars scattered over an area 20 arcminutes across. ☐ **SEEN IT**

2 IC 5217

Located halfway between the left star of the Mini-W (mag. +4.4 Beta (β) Lacertae) and the middle star (mag. +4.6 4 Lacertae) is the faint and easily overlooked planetary nebula IC 5217. At mag. +12.7, the 6-arcsecond nebula requires a decent aperture to see well and a high magnification is needed to reveal any shape. Its colour is green or blue-grey, and at less than 250x magnification it appears more like a green star. A 6-inch scope reveals the nebula's small oval shape. Larger instruments will show it to contain an inner disc with north and south extensions. Under good conditions, a bright spot can be seen to the west of the core. ☐ **SEEN IT**

3 ME 2-2

Planetary nebulae are often quite small and star like, which makes them hard to find. This is certainly the case with Me 2-2, which lies about 20 arcminutes to the east of the second star at the right of the Mini-W (mag. +4.3 5 Lacertae). At mag. +11.5 it is not especially faint for a planetary nebula, but its size is a challenge, being only 1 arcsecond across. Consequently, in a small telescope it looks much like a star; it takes a larger instrument at around 400x magnification to show you any different. An OIII filter may help Me 2-2 to stand out better. ☐ **SEEN IT**

4 NGC 7209

After the diminutive size of Me 2-2 it's refreshing to find something with a decent apparent diameter once again. NGC 7209 is a mag. +6.4 open cluster, measuring 24 arcminutes across. It lies 2.75° to the west of the right hand star of the Mini-W (mag. +4.6 2 Lacertae). Despite its integrated magnitude the cluster is actually quite faint. A 6-inch scope reveals about 40 stars, with the number increasing to around 100 in a 12-inch instrument. There's little concentration to be had here, and the scattering of cluster stars is fairly even. Look at the cluster with a low-power eyepiece and a number of the stars seem to form distinctive right-angle patterns. ☐ **SEEN IT**

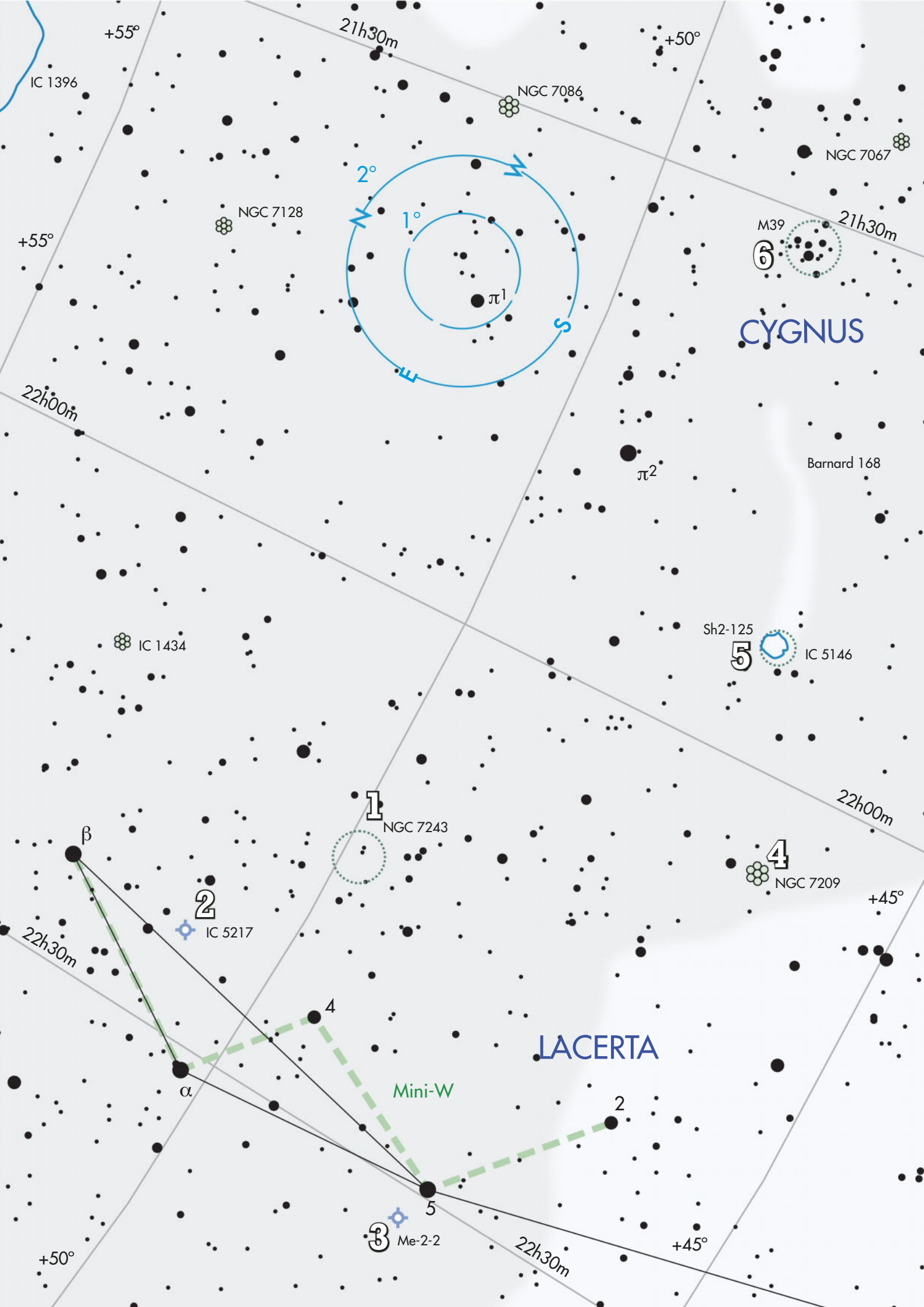
5 SH2-125

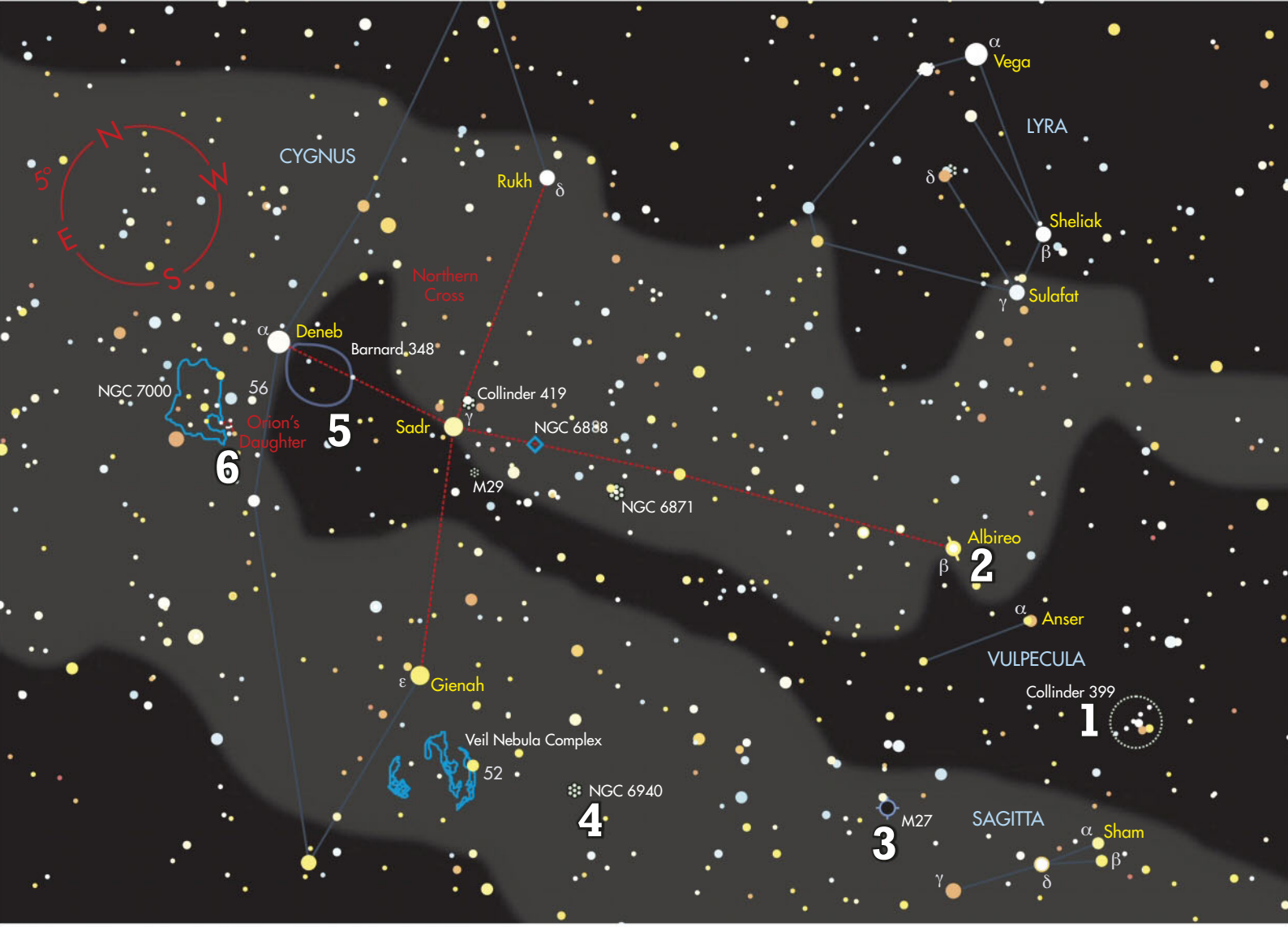
Sharpless 2-125 is a 12-arcminute circular patch of reflection and emission nebulosity known as the Cocoon Nebula. It is associated with the embedded star cluster IC 5146 and this catalogue identifier is sometimes used to refer to the Cocoon. A 6-inch telescope shows the Cocoon's misty patch encircling two mag. +9.5 stars; larger instruments reveal irregularities in the nebula's edge and mottling across its surface. Low magnification shows the nebula to be at one end of a pronounced dark lane – the dark nebula Barnard 168. It almost looks like the Cocoon's eating through the rich Milky Way star field here. Find it 2° west and slightly to the north of NGC 7209. ☐ **SEEN IT**

6 M39

Despite lying in one of the richest parts of the sky, the large constellation of Cygnus the Swan contains only two Messier objects: M29 and M39. The latter can be found midway between mag. +1.3 Deneb (Alpha (α) Cygni) and mag. +3.8 Alpha (α) Lacertae, the second star in from the left of the Mini-W. The cluster is distinctive because of its triangular shape, but despite its mag. +4.6 brightness it can be surprisingly tricky to zone in on due to the Milky Way star field. A 6-inch scope reveals about 30 stars in the cluster, with the number climbing to 50 or more with a 10-inch scope. Internally, the cluster shows no really noticeable condensation. ☐ **SEEN IT**

CHART: PETE LAWRENCE, PHOTO: HUBL BERNHARD/ ASTRONOMER ARBEITSKREIS SALZKAMMERGUT


+55°
21h30m
+50°
IC 1396
NGC 7086
NGC 7067
2°
1°
NGC 7128
+55°
M39
6
21h30m
π1
CYGNUS
22h00m
π2
Barnard 168
IC 1434
Sh2-125
5
IC 5146
1
NGC 7243
22h00m
β
4
NGC 7209
+45°
2
IC 5217
22h30m
4
LACERTA
α
Mini-W
2
5
3
Me-2-2
+50°
22h30m
+45°



Binocular tour

July brings a wardrobe accessory, a true binary and the Hunter's mini-me

With Stephen Tonkin

☑ Tick the box when you've seen each one

1 THE COATHANGER

10x 50 We start this month's tour with a popular star-party piece, an asterism variously designated Collinder 399, Brocchi's Cluster and Al-Sufi's Cluster, but commonly known as the Coathanger. It lies 5° south of mag. +4.4 Anser (Alpha (α) Vulpeculae); even small binoculars will reveal the 10 bright stars that give it its common name. The asterism spans 1.5°, which means that it will stay within the field of view for long enough for several consecutive observers to see it in mounted binoculars. ☐ **SEEN IT**

2 ALBIREO

10x 50 Double star Albireo (Beta (β) Cygni), the head of Cygnus the Swan, is a good test for 10×50 binoculars. If you cannot initially see two stars, try mounting your binoculars to increase their stability. The members of this superb double are separated by 34 arcseconds. The mag. +3.1 primary is a deep orange-yellow, while the fainter (mag. +5.0) secondary is a bright sapphire-blue. Albireo is thought to be a true binary 386 lightyears away, its stars separated by 0.12 lightyears and taking 75,000 years to orbit one another. ☐ **SEEN IT**

3 THE DUMBBELL NEBULA

10x 50 Although it is not the only planetary nebula that is visible in 10×50s, the Dumbbell Nebula, M27, is significantly easier to see than any other, even in moderately light-polluted skies. If you place mag. +4.4 Sham (Gamma (γ) Sagittae) at the south of a 5° field of view, the Dumbbell Nebula will be just north of centre. This elongated glow of light will initially appear rectangular but, with patience, you should make out the narrowing in the middle that gives it its common name. ☐ **SEEN IT**

4 NGC 6940

10x 50 NGC 6940 is a very pretty open cluster that ought to be far better known. To find it, start at mag. +2.5 Gienah (Epsilon (ε) Cygni) and navigate just over 3° due south to mag. +4.2 52 Cygni. Continue the same distance to the southwest, where you will find an oval glow that appears to be the about same size as the Moon. As you study this glow, you should be able to resolve eight or more stars, depending on your sky conditions. This is NGC 6940 – it is about 2,700 lightyears away and is thought to be about 800 million years old. ☐ **SEEN IT**

5 THE NORTHERN COALSACK

10x 50 Slightly to the east of a line from mag. +3.4 Deneb (Alpha (α) Cygni) to mag. +2.2 Sadr (Gamma (γ) Cygni) is Barnard 348, one of several regions that is sometimes called the Northern Coalsack. EE Barnard was a 19th-Century American astronomer who catalogued many of what had been thought since William Herschel's time to be 'holes' cutting through the Milky Way. By carefully studying photographs of these holes, taken with the 40-inch refractor at the Yerkes Observatory, he realised their true nature: clouds of obscuring gas and dust. ☐ **SEEN IT**

6 ORION'S DAUGHTER

15x 70 Look 2° southeast of Deneb to find mag. +5.1 56 Cygni. A little more than 1° southeast again is a pair of 7th-magnitude stars separated by about 10 arcminutes. These are the 'knees' of a tiny Orion-shaped asterism of seven stars. The 'belt' is comprised of three 9th-magnitude stars about 10 arcminutes north of the knees, while the widely spaced and slightly lopsided shoulders are 15 and 20 arcminutes farther north. The left shoulder marks the tip of 'Florida' in the North America Nebula, NGC 7000. ☐ **SEEN IT**

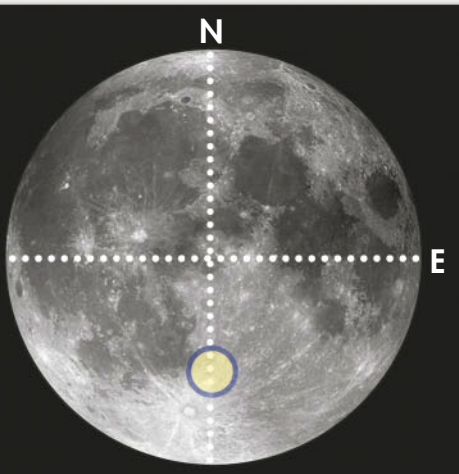
CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Crater Walther

STATISTICS

TYPE: Crater
SIZE: 141km
AGE: 3.85-3.92 billion years old
LOCATION: Latitude 33.2°S, longitude 0.6°E
BEST TIME TO OBSERVE: Six days after full Moon or first quarter Moon (8-9 July or 23 July)
MINIMUM EQUIPMENT: 10x binoculars



CRATER WALTHER SITS on the centre line of the lunar near side, roughly a quarter of the way up from the southern limb. It's a well-defined feature with a roughened but clearly visible rim. Centre-to-centre, Walther sits 420km to the northeast of the prominent ray crater Tycho.

There are many chains of craters visible on the Moon. Several of these are triplets of large craters, for example that formed by Theophilus, Cyrillus and Catharina around the edge of the Mare Nectaris farther east. Then there's the distinctive trio of Ptolemaeus, Alphonsus and Arzachel to the north. Walther sits at the southern end of a similarly sized triplet, starting an Alphonsus-diameter south of Arzachel. It starts with 118km-wide Purbach, which overlaps the degraded remains of Regiomontanus (126km wide), which itself reaches south but doesn't quite touch Walther (141km). Over to the west of Walther lays the immense 235km walled plain Deslandres. To the northeast is distinctive circular crater Werner (70km) and Aliacensis (80km).

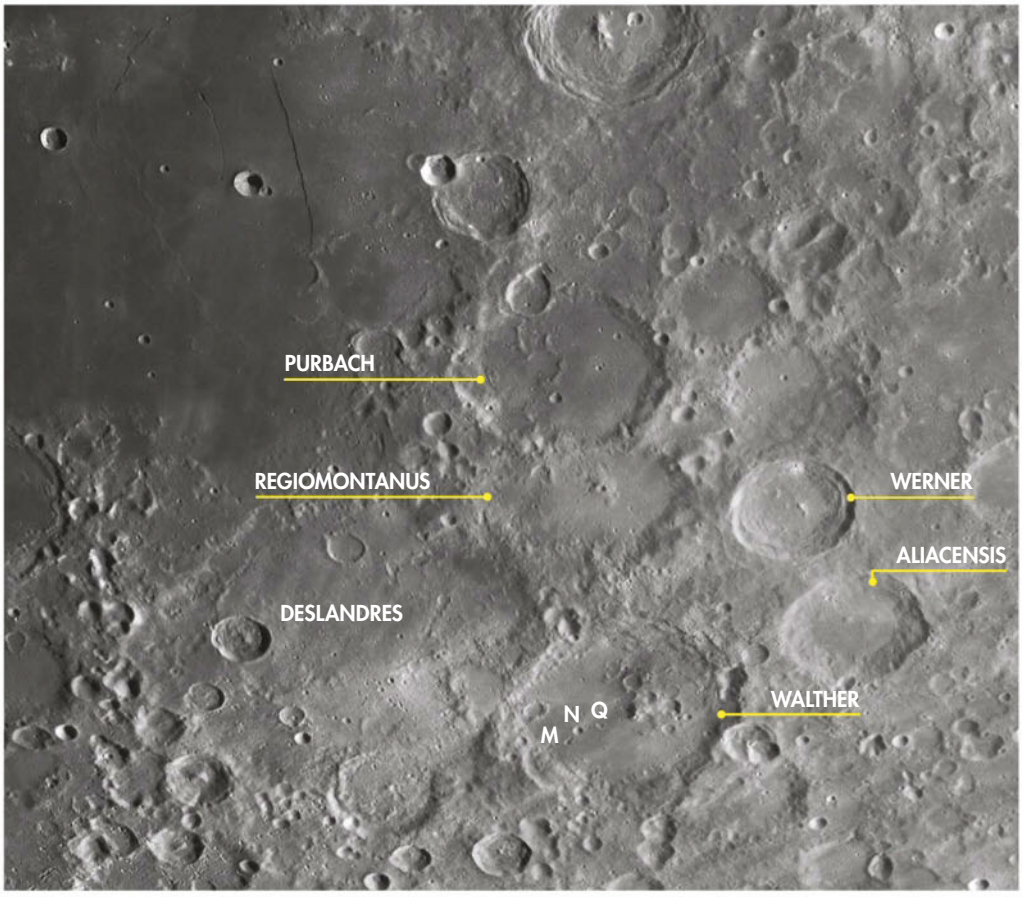
Walther exhibits a largely flat floor interrupted by several small craterlets and an offset central mountain complex to the northeast. Various craters appear to have interfered with the structure of the mountains and extended the roughness of this region towards the northeast rim. The highest peak rises upwards for about 2km and casts an impressive pointed shadow when the terminator is not too far away.

"The triplet of craterlets in Walther's southwest is a good test for a telescope"

There is a triplet of small craterlets in Walther's southwest quadrant and these are a good test for telescope optics. In the centre lies Walther N (6km), a viable target for a 4-inch scope. Slightly to the southwest is Walther M (5km), a slightly more difficult target for a 4-inch scope, but still possible under good seeing conditions. An 8-inch scope will be needed to resolve Walther Q (4km), which lies between N and the central mountain complex.

The shape of Walther's rim appears slightly squared off, an effect heightened by a straight inner edge to the southwest. With high magnification it looks like something has bulldozed the floor of the crater flat, creating a straight edge against the rim.

Many features on the lunar surface have interesting stories attached to them and Walther is no exception. In 1979 the International Astronomical Union (IAU) approved the name Walter for a tiny crater just over 1km across, located in the border area between Oceanus Procellarum and Mare Imbrium. No one seemed to notice that the crater that we now know as Walther was also called Walter. In 2000, it was suggested that large Walter be renamed Walther to remove the confusion; some amateur astronomers were unhappy with the change and refused to switch to the new name, a situation that still persists in some cases.



Being relatively close to Tycho, Walther's floor has been tiger-striped by ejecta thrown out by that impact

Astrophotography

Imaging the Venusian crescent

RECOMMENDED EQUIPMENT

High frame rate camera, telescope on an equatorial mount with setting circles, full aperture solar filter, infrared filter, planetarium software for Sun and Venus positions

Venus's crescent will not be easy to see in darkness in July; daytime imaging offers an alternative

VENUS HAS BEEN prominent in the evening sky for a few months. It is an inferior planet, which means that its orbit is smaller than that of Earth's. This also means that as the angle between the Sun, Venus and Earth changes, Venus exhibits phases. On 6 June, that angle was 90°, which meant that Venus should have been showing a half phase. In reality for evening elongations the half phase of Venus arrives a few days early due to a phenomenon known as the Schröter effect.

After the evening appearance of Venus has passed 50%-lit, the planet slips into a beautiful crescent. As the distance between us and Venus is also reducing at this time, the crescent becomes large too, eventually gaining it the prize for the largest apparent diameter of any planet seen from Earth.

That's the good news. Unfortunately, the location of Venus in the sky has been gradually getting worse for evening twilight viewing, its altitude dropping markedly each night after sunset. This makes seeing this amazing crescent hard, but there is another way.

Venus is an incredibly bright planet that can be seen in a blue daylight sky – if you know where to look. This provides an opportunity to locate it when it's much higher than it is around sunset. The bright blue sky also has a calming effect on the intensity of Venus, which when viewed against a darkening twilight sky, can overpower the view somewhat.

So this month, there are two parts to the challenge of getting an image of Venus. The first involves locating it with your telescope, the second obtaining and processing your capture.

Locating Venus in the daylight sky is not without risk as the Sun will be up. In addition, Venus is in conjunction with the Sun in the middle of August, so by the end of July, its apparent distance from our star will have decreased significantly. As ever, it pays to take extra care to make sure you don't do something that can put yourself or your equipment in danger.

Ironically, the Sun is the best reliable marker to finding Venus but this adds extra pressure on making sure that you get your safety routines worked out. When pointing your scope at the Sun, a solar safety filter must be fitted. Any secondary scopes, such as finders, must also be protected or capped. It's useful to create a routine checklist that you work through to make sure that you don't have any accidents.

The basic routine is to protect your scope for solar viewing and then point it at the Sun. Centre up the Sun's disc and then set your mount's setting circles to the coordinates for our star. Offsetting the telescope's position so that the setting circles read the correct position of Venus should then have you pointing at the right patch of sky.

Once you've found Venus, then you're ready for the next step, which is imaging the crescent. If you're not too familiar with the routine for finding Venus during the day, then the above may sound a bit long winded. However, having located it once, subsequent finds become much easier. Always check to make sure that the Sun's light is not passing down the telescope tube by peeking down the front of the scope – not through the eyepiece.

KEY TECHNIQUE

GO INFRARED FOR SHARPNESS

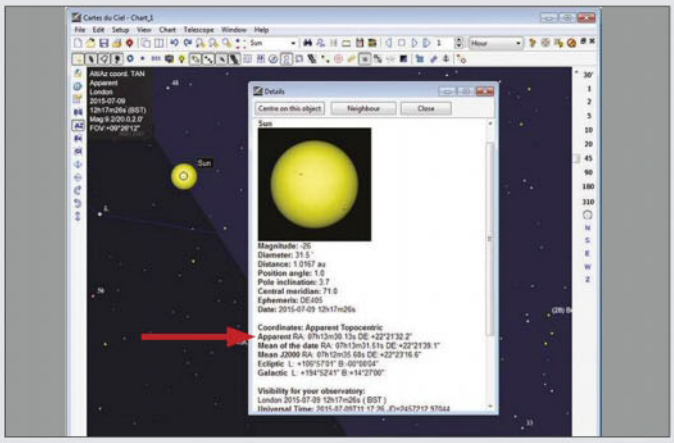
Venus is a beautiful planet to image, especially in a crescent phase. But this year's appearance of Venus is not suited to viewing the crescent in evening twilight, so it'll be necessary to locate the planet in daylight in order to get a decent shot. Once found, the old trick of using an infrared-pass filter can be used to produce a good sharp view. Longer wavelengths of light – such as infrared – tend to be less affected by seeing issues. An infrared filter will also help to improve contrast by blocking the blue light of the sky.

Send your image to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

STEP-BY-STEP GUIDE

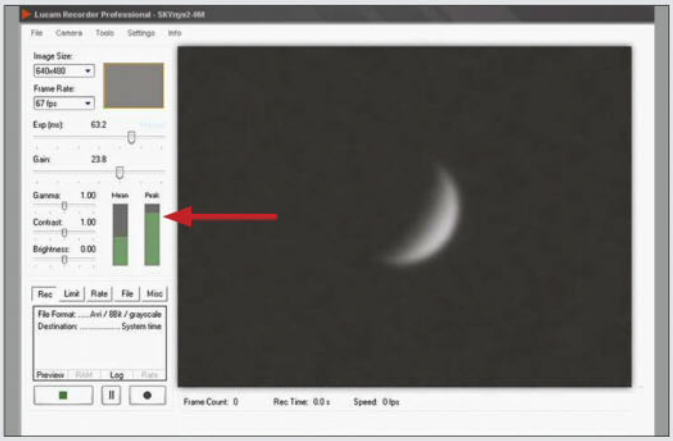
STEP 1
Get your telescope ready and fit the solar filter before pointing it at the Sun. Cap any finders present. Use an eyepiece to get the Sun centred and focus accurately. Note down the visual focus point; a soft pencil can be used to mark your drawtube if it doesn't have ruler graduations. Replace the eyepiece with your camera and refocus. Again, note the focus position.



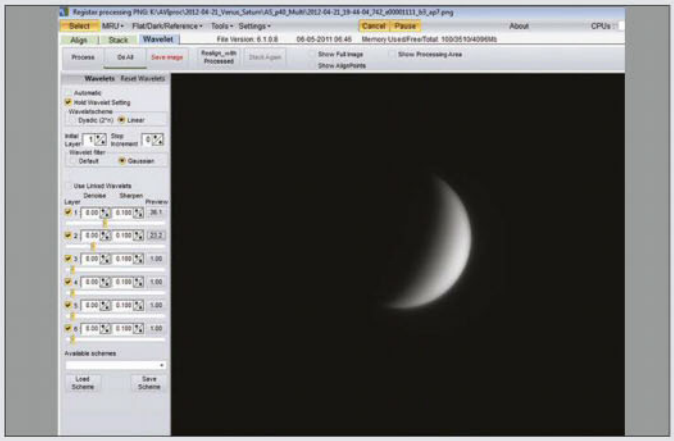
STEP 2 Replace the camera with the eyepiece and refocus again. Centre the Sun's disc, then look up the Sun's RA and dec. for the current date and time in a planetarium program. Rotate the mount's setting circles to reflect these values. Consult your mount's documentation if you are not sure how to do this.

STEP 3 Look up the RA and dec. of Venus and move your scope so that the setting circles match these values. As a rough guide, your scope should move east and south (left and down). When you are in position (you must be pointing away from the Sun) uncap the finder and remove the solar filter. See if you can spot Venus in the finder.

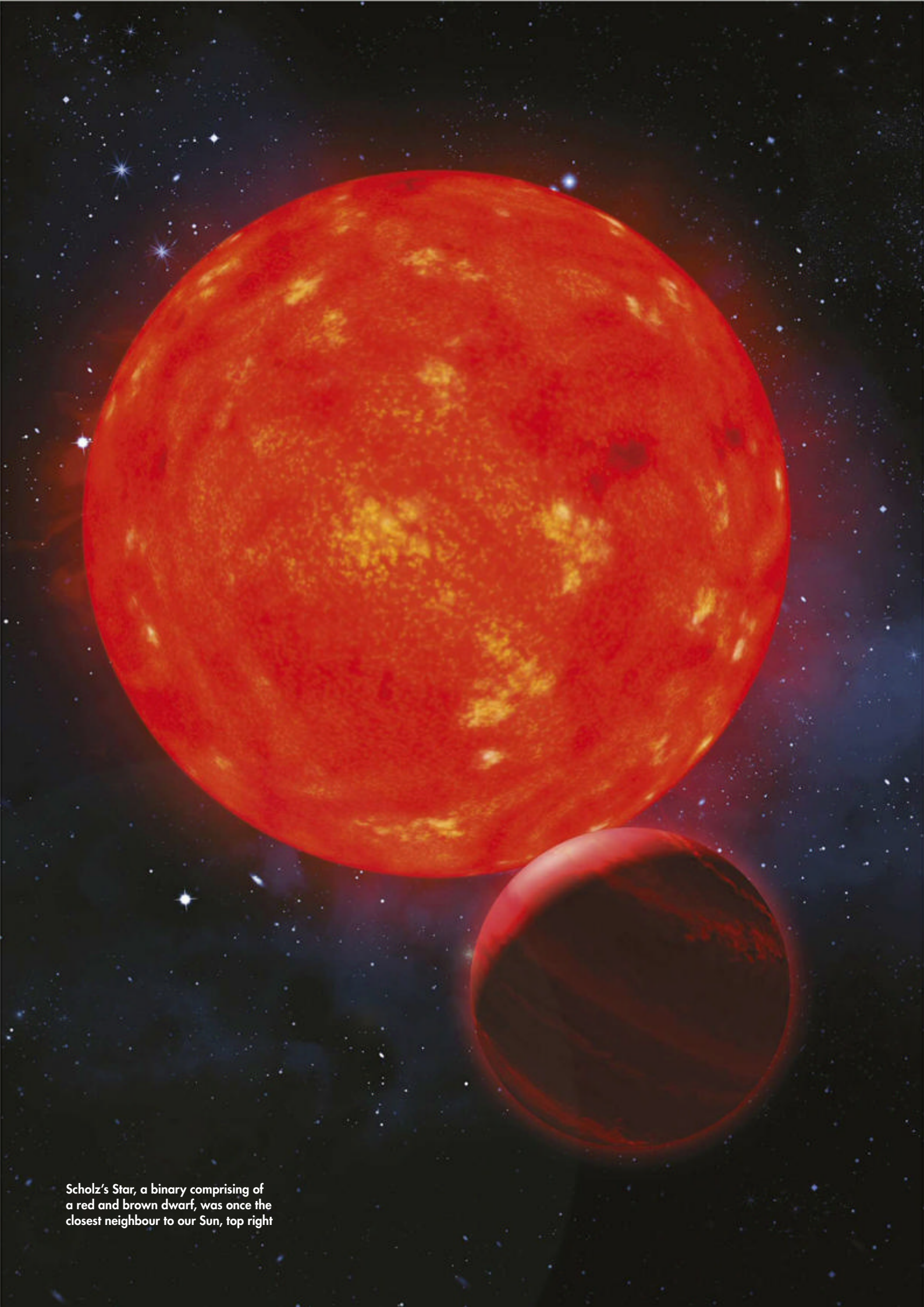
STEP 4
If Venus isn't visible, refit the solar filter and recap the finder, then start over from Step 1. Once you do locate the brilliant planet, centre it in the view and replace the eyepiece with your camera. Focus the camera to the position you jotted down in Step 1 and try and locate Venus on your computer screen. A cloth over your head and screen will make it easier to pick out Venus against the blue sky.



STEP 5 Focus as accurately as possible. Adjust the camera exposure and gain so that the planet is bright but not saturated, with no white present. Take at least 1,000 frames. You could also try upping the image scale with a Barlow lens or equivalent – if you lose Venus, reset to the default setup and focus position from Step 1.



STEP 6 Process the resulting capture file in your favourite registration and stacking program. Save without sharpening, as a lossless png or tiff file. Reload this file in freeware RegiStax and wavelet sharpen. Save the results under a different filename. You can go back to the original if you need to start again.



Scholz's Star, a binary comprising of a red and brown dwarf, was once the closest neighbour to our Sun, top right

CLOSE ENCOUNTERS OF THE STELLAR KIND

Only 70,000 years ago, a binary star passed within an astronomical whisker of our Sun, writes **Govert Schilling**

Some 70,000 years ago, a young Homo sapiens looked up to the night sky. Leaning against a rock, he paused to rest and marvel at the invariable patterns of the stars. Then, suddenly, close to one of the bright stars of a large, conspicuous grouping, he noted a speck of light that he was sure hadn't been there before. Unknowingly, our distant ancestor witnessed the temporary flaring of the Sun's then-nearest neighbour.

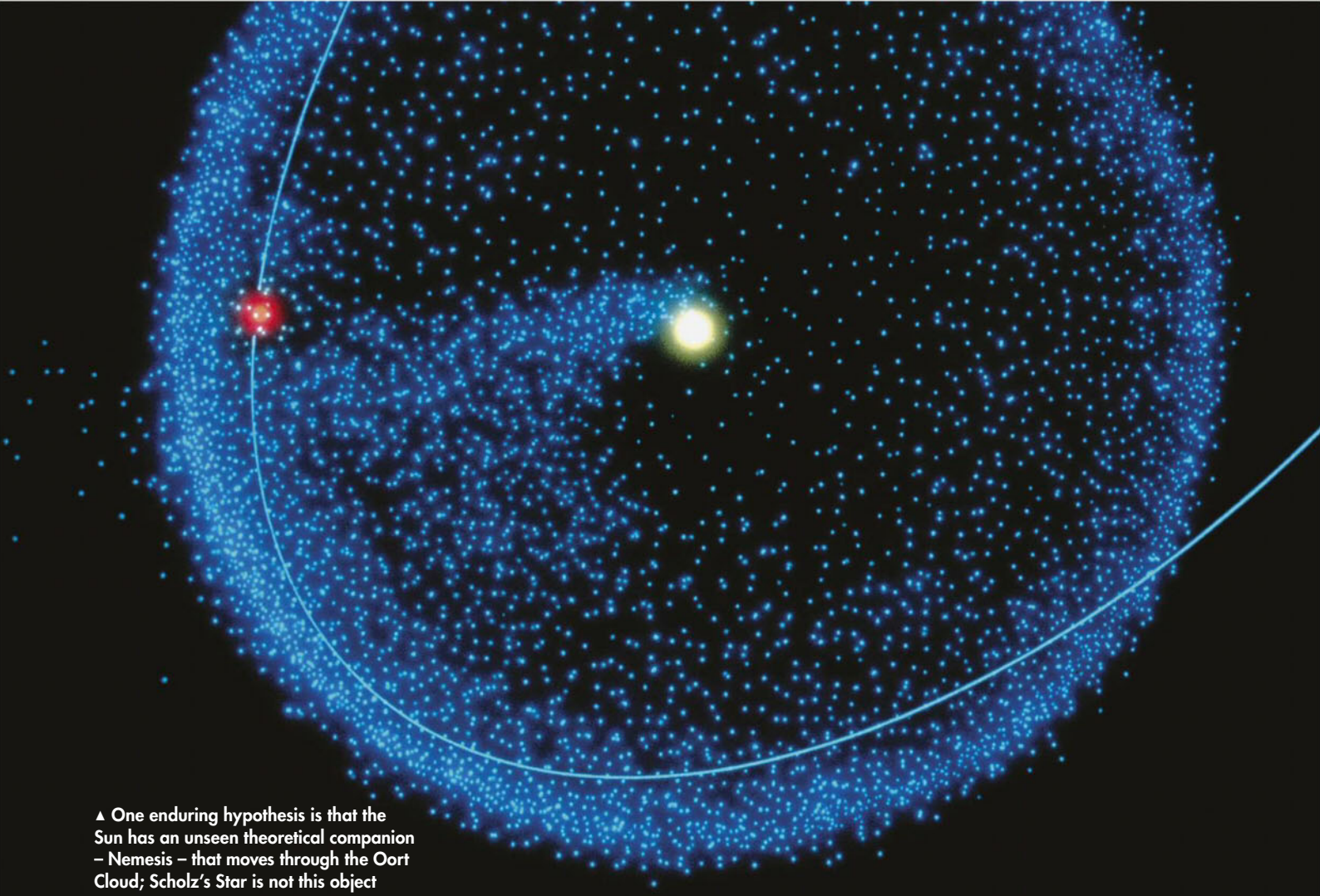
Millennia later, Ralf-Dieter Scholz of the Leibniz Institute for Astrophysics Potsdam in Germany discovered that a mag. +18.0 star in the constellation Monoceros, designated WISE J072003.20-084651.2, is a relatively nearby low-mass, low-luminosity red dwarf. A few months later, in October 2014, Adam Burgasser of the University of California, San Diego, pinned down its distance at just under 20 lightyears, and found that the red dwarf is actually part of a binary system with an even lower-mass brown dwarf.

From the start, astronomers realised that Scholz's Star, as it is now known, is special. Despite being nearby, its apparent movement across the sky is very small: a mere tenth of an arcsecond per year, corresponding to a transverse velocity (the speed of movement at right angles to our line of sight) of around 3km/s. But Doppler measurements reveal that the star is speeding away from us at 83km/s. A quick calculation showed that some 70,000 ago the star must have passed very close to the Sun.

▲ Scholz's Star now resides in the faint constellation of Monoceros

"I couldn't believe the result myself when I crunched the numbers on this star," says Eric Mamajek of the University of Rochester, New York. At its closest Scholz's star came within 0.8 lightyears of the Sun – one-fifth of the current distance to Proximia Centauri – speeding across ▸

NASA/ESA AND G. BACON (STSCI), ISTOCK X 2, © GALAXY PICTURE LIBRARY/ALAMY



▲ One enduring hypothesis is that the Sun has an unseen theoretical companion – Nemesis – that moves through the Oort Cloud; Scholz's Star is not this object

▸ Ursa Major with a proper motion of more than one arcminute per year. And although it only shone at mag. +11.0, a brightness it would take a decent amateur telescope to detect, it probably flared up to naked-eye visibility every couple of years or so, thanks to the giant magnetic flares that low-mass red dwarfs are known to produce.

The discovery generated a lot of attention and media coverage, but some of it was based more on pseudoscience rather than actual facts. Around the same time as the close approach, the Toba supervolcano in Indonesia exploded. "People's first instinct was to try to connect the two events," says Mamajek. "But the star's tidal forces on Earth were two quadrillion times weaker than the Moon's, so the Earth didn't feel any effect at all."

Postcards from the Oort Cloud

Still, Scholz's Star almost certainly passed through the outer reaches of the Oort Cloud – the spherical distribution of trillions of comets surrounding the Sun. Could gravitational perturbations have triggered showers of comets on Earth? Very unlikely, explains Mamajek. Every million years something like 10 stars whiz through the outer regions of the Oort Cloud. But this region is sparsely populated and the vast majority of these stars are not massive or slow-moving enough to produce much of a disturbance. And stars sailing through the denser inner parts of the Oort Cloud are extremely rare. "Near-Earth asteroids are a much more important hazard," says Mamajek. "I am not losing sleep over Oort Cloud comets."

"Every million years something like 10 stars whiz through the outer regions of the Oort Cloud"

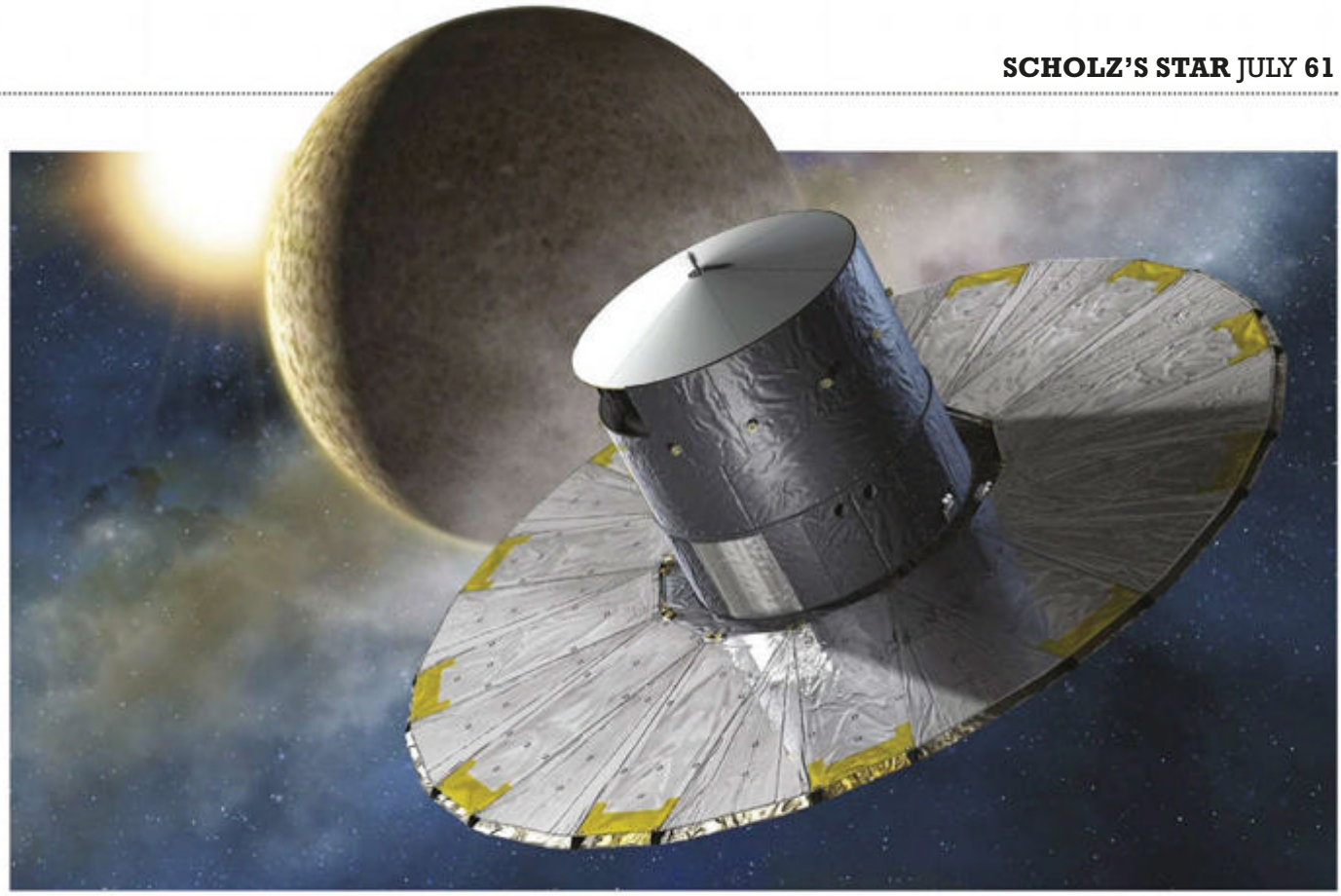
WAS THIS STAR **NEMESIS?**

In 1984, paeleontologists David Raup and Jack Sepkoski discovered an apparent 26-million-year periodicity in mass extinctions on Earth. Astronomers suggested that the Sun might have a red or brown dwarf companion in an eccentric orbit, taking it through the Oort Cloud every 26 million years. Nemesis, as this hypothetical 'Death Star' was called, would stir up cometary orbits, and produce impact showers on our home planet.

So with the discovery of Scholz's Star, has Nemesis finally been found?

Not at all. The dwarf binary that comprises Scholz's Star is not (and has never been) gravitationally bound to the Sun – its velocity is way too high. Moreover, the components of a multiple stellar system are usually all the same age. In contrast, Scholz's Star appears to be much older than the Sun. In fact, the existence of Nemesis has been ruled out by NASA's WISE (Wide-field Infrared Survey Explorer) satellite, and the cause of the apparent mass extinction periodicity remains unknown.

JON LOMBERG/SCIENCE PHOTO LIBRARY, ROGER HARRIS/SCIENCE PHOTO LIBRARY, ESA–D. DUCROS/2013



▲ Gaia is in the midst of its mission, mapping the cosmos from the second Lagrangian point

Meanwhile, ongoing surveys continue to find small stars and brown dwarfs close to the Sun, says Todd Henry of Georgia State University in Atlanta, who leads one such programme, called RECONS (Research Consortium on Nearby Stars). "Since 2010, there have been 22 new stellar systems and 22 new brown dwarfs revealed within 10 parsecs [32.6 lightyears]," says Henry. "Scholz's Star would be system number 45. It's as if our neighbourhood continues to get more crowded, although it has of course always been that way – we just hadn't met all of our neighbours."

The region is only going to get more crowded though, as ESA's Gaia mission, which launched in late 2013, reveals even more nearby stars. But whether or not any of those new discoveries will have the right motions in our Galaxy to cross – or to have crossed – the path of the Sun remains to be seen, says Henry. "A very close approach in the past is already ruled out," he notes. "After all, our Solar System has been here for 4.6 billion years."

According to Mamajek, "Stars come closer than Scholz's Star maybe once every ten million years or so". We're only just beginning to really get to know our local neighbourhood, so perhaps we'll find just when our next close encounter will be.

ABOUT THE WRITER

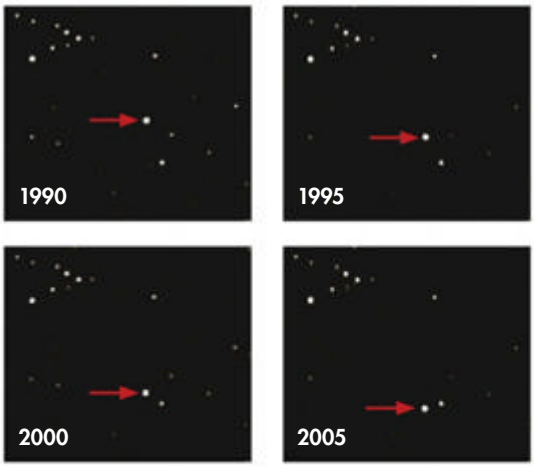
Govert Schilling is an astronomer and author from the Netherlands. He is co-author of *Europe to the Stars – ESO's First 50 Years of Exploring the Southern Sky.*

THE SHIFTING **COSMOS**

When a bird flies overhead, it zips past in only a few seconds, but a jetliner high up in the sky appears to hardly move, even though its travelling hundreds of times faster. That's because of its much larger distance, of course. The same holds true for stars: nearby stars generally have a much larger apparent motion across the sky than more distant ones – unless they are moving almost directly away from us, and that is the case with Scholz's Star.

The star that currently has the largest apparent motion (10.3 arcseconds per year) is a red dwarf known as Barnard's Star, at a distance of just six lightyears. Around the year 11,800 it will approach the Sun to within some 3.75 lightyears, only to start receding again. Incidentally, Proxima Centauri (the Sun's current nearest neighbour, at 4.2 lightyears) will come to within 3.11 lightyears in around 27,000 years from now.

Should we be worried by stars whizzing through space at a wide range of velocities and directions? Certainly not. As Eric Mamajek of the University of Rochester notes: "Space is a very big place – there is a lot of distance between the stars, even during these 'flybys'."



▲ Barnard's Star has visibly moved in the past 10 years

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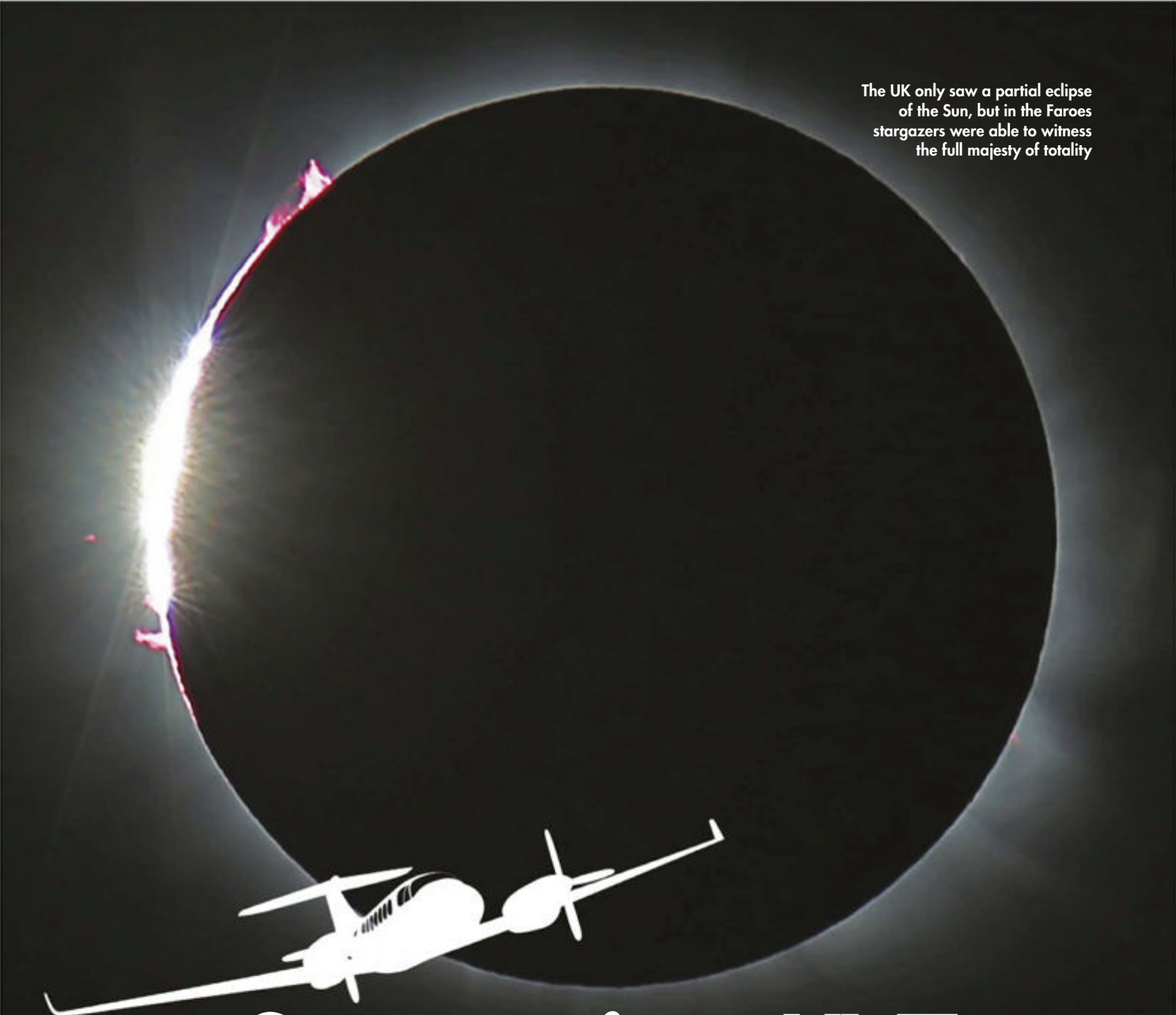


The UK only saw a partial eclipse of the Sun, but in the Faroes stargazers were able to witness the full majesty of totality

PETE LAWRENCE, ISTOCK

Stargazing LIVE

AN ECLIPSE FOR THE masses

BBC cameraman **Mark Payne-Gill** was set the task of recording the 2015 total solar eclipse live from a plane for *Stargazing LIVE*, little knowing what a challenge it would be

Mark in front of 'Totality One', collimating and testing his rig before installing it in the plane

While planning what to cover for *Stargazing LIVE*, the producers were wondering how they could possibly go one better than last year's mission to film the aurora. But the answer soon became clear. The stand out event in the 2015 astronomical calendar was a total solar eclipse in the Faroe Islands the following March. The show's producers knew it was the event to capture the imagination of millions of *Stargazing LIVE* viewers.

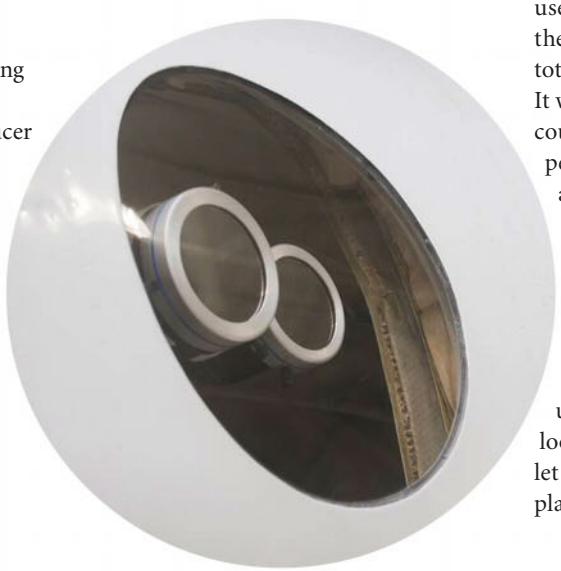
Given the weather conditions in the North Atlantic in March, there was a strong likelihood that the eclipse would not be visible from the ground. So series producer Paul King had a big question for me: could we broadcast the total eclipse live from a plane above any clouds?

At least the eclipse was guaranteed to happen, unlike the aurora, but still it was a hard question to answer. Training long focal length lenses through a curved plane window at the Sun from a moving and turbulent platform seemed crazy. There would be nowhere to hide if it failed – this would be live for all to see. But, if it worked then we would be able to share the most spectacular event in nature with an audience of millions. Little did I realise this was going to be my biggest challenge yet.

With less than four weeks to go we developed a strategy. Using our the same aircraft as last year, the plan was to film the eclipse with telescopes. A receiving truck on the ground would lock onto our broadcast signals while we flew. The flight path was timed so that when the two minutes of totality occurred our main cameras would be facing the eclipse.

The most obvious challenge was how I would track and keep the images of the eclipse steady. I decided on the low-tech solution of manually tracking the eclipse with two main telescopes, one offering a close up and the other a wider view. I had to use solar filters for the partial phase, but these would need to be removed just before totality if I wanted to capture the corona. It wouldn't be steady by any means, but it could still be spectacular all the same, and perhaps even add to the drama with a more 'live' feel.

"Training long focal length lenses through a curved plane window at the Sun from a moving and turbulent platform seemed crazy"

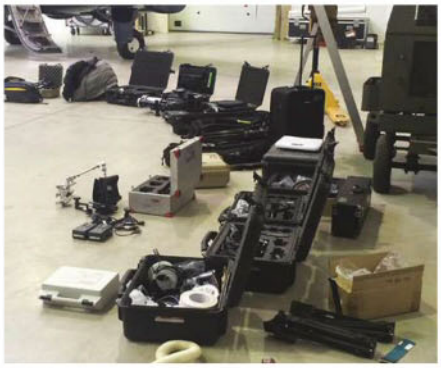


Mission impossible?

As I boarded the plane in Antwerp, Belgium, rigged and ready to go, my thoughts turned to the enormity of the task ahead. There were so many unknowns. What would the quality look like? Could I even locate the Sun, let alone track it from our moving platform? Suddenly, these thoughts were

MARK PAYNE GILL X 6, ALASTAIR DUNCAN X 2

▲ Pilot Paul Ewers discussing the eclipse-chasing flight plan with director Andy Reid



▲ This is only part of the 200kg of kit Mark needed to film the eclipse while in midair

▲ Mark and Ian 'Bungie' Bennet run a brief test of the setup on the trip to the Faroes

▲ Mark with Liz just before boarding Totality One – doing his best to hide his nerves

▲ The aerial team (left to right): assistant producer Alastair Duncan, presenter Liz Bonnin, pilot Emmanuel De Craene, director Andy Reid, pilot Paul Ewers, engineer Ian 'Bungie' Bennet and Mark

interrupted as we were ordered to evacuate the plane: a thick cloud of smoke had engulfed the wing when the pilots had attempted to start the engines. With less than 24 hours to go, I was now wondering if we were ever going to get to the Faroes, let alone the eclipse.

The fault was quickly fixed, but it didn't help my nerves. We finally took off an hour later, stopping on the way to pick up presenter Liz Bonnin and the rest of the *Stargazing LIVE* aerial team. This gave me my only opportunity to test the cameras and my skills at tracking the Sun from 'Totality One' (as we had renamed the plane) during the short time left to the Faroes.

The reassurances of a good test were soon overtaken by the weather ▸

MARK'S **EQUIPMENT**

I had double the number of cameras this year and the task was complicated by a strict weight limit on the aircraft. Getting the right telescope and camera combination was therefore crucial. Fortunately we found the perfect solution: the compact and lightweight Tele Vue TV60 60mm refractor and an Explore Scientific 80mm apo refractor. The great optics of the Tele Vue combined with a simple design made it an ideal choice. A Mallincam Signature camera was coupled to this: its 0.25-inch sensor produced a perfect image scale for close-ups. The 80mm apo was attached to a Canon C300 video camera. Its large sensor would show a wider view of totality and reveal the solar corona. As a back up, and also for filming the partial phase, I had a Canon HJ 28-500mm broadcast zoom lens for use with the Canon C300. If turbulence was severe this offered a wider shot, and I could zoom in if conditions allowed.

The Canon C300 and Mallincam HD cameras were attached to solar-filtered 80mm and 60mm refractors respectively, using a custom mount

The wide-angle view of totality; Venus and Mercury are clearly visible either side of the Sun

▸ ahead as we descended to Vàgar Airport in the Faroes. Thick clouds swept in so fast that the pilots had to abort our landing; the runway had disappeared in heavy mist and rain. We climbed into the sky once again and banked around for our second attempt. If we didn't land this time we'd have to turn back to Scotland with our remaining fuel. Thankfully we made it. Just.

Alone in the clouds

We took off at 7.30am on the day of the eclipse, leaving the thick cloudy skies of Vàgar beneath us. 'Bungie', our highly skilled engineer, had the unenviable task of broadcasting our transmission signals to the outside world. Our signals were very weak and the ground station could barely pick us up. With only five minutes to go before the live transmission started on BBC One, the main studio in Jodrell Bank had no idea where we were. Nobody could hear us.

THE VIEW **FROM HOME**

In the lead up to 20 March, the excitement was enormous, with shops running out of eclipse glasses weeks beforehand and pairs selling on eBay for over £20 each, though *BBC Sky at Night Magazine* readers had already received a free pair with their March issue. On the day itself, astronomy groups across the country went out into the public armed with everything from solar telescopes to colanders to make sure as many people as possible could watch the partial eclipse that would be visible from the UK and the rest of northern Europe. The story was one of the most talked about topics of the day as people gathered outside to watch the Sun with the Moon passed in front of it.

Unfortunately, for much of the UK the day was cloudy, though many managed to catch a glimpse of the Sun through a break in the clouds. For those that missed it, *Stargazing LIVE* was on hand so that even those under the cloudiest skies could share in the total eclipse. A special morning show was broadcast to coincide with the eclipse and share totality, with a massive 4.7 million people tuning in to watch. It was an incredible event that millions of people all over the world were able to share in.

▲ Our own outreach event near to the *BBC Sky at Night Magazine* offices was an enormous success, with hundreds of people turning out to watch the spectacular eclipse

MARK PAYNE GILL X 2, ALASTAIR DUNCAN, PAUL KING, BBC STEVE MARSH

▲ Mark manually tracked his custom solar telescope and camera rig while filming – he didn't have a huge amount of space to do it in

▲ The production team hold their breath during this heart-stopping moment in the gallery during the live transmission

▲ Liz Bonnin takes a break to enjoy the view during the partial phase

▲ The eclipse just after third contact, as recorded by the Mallincam Signature HD through a 60mm refractor; the red tint is an image artefact

I was giving up hope, when suddenly voices crackled over the airwaves. It was the studio at Jodrell! Our signals were extremely weak but Bungie had boosted it just enough for it to work, though if we lost even a small amount of power we'd go off air completely.

While we were being counted down to the show I was struggling to locate the Sun with the partial eclipse camera, but couldn't find it in time. Liz introduced us to viewers around the world while my viewfinder remained blank! A quick glance through the window revealed the Sun was 30° behind us. The pilots were dealing with 145km/h crosswinds and had adjusted the track accordingly, forgetting that the Sun was in the wrong place for the camera.

I had to get ready for totality and our next live transmission while the pilots aimed the plane along the correct heading to place the Sun directly opposite our cameras. This time it was spot on. Second contact was only minutes away as I centred the crescent Sun in both telescopes. Turbulence was making things tricky so I had to work hard at keeping the image of a crescent Sun edging towards totality on the screens.

> "I could clearly see the solar atmosphere and prominences appearing along the trailing edge of the Moon"

The moment of truth

Viewers around the world were now watching with us. The time had come to remove the solar filters – a nerve-racking moment. We removed them from both telescopes. For what seemed like an eternity, the camera sensors were flooded with light and worse, heat. I needn't have worried though, as seconds later with the exposure adjusted the diamond ring appeared. I could clearly see the solar atmosphere and prominences appearing along the trailing edge of the Moon just moments from second contact and the beginning of totality. All the while I concentrated on keeping the eclipse in frame. In a blink of an eye we reached the edge of the shadow, signalling the end of totality.

Having achieved the almost impossible we all started breathing again, able to enjoy the closing stages of the eclipse.

The adrenaline buzz we all felt was amazing. The impact started to sink in as we came into land. Before we had even touched down I received an overwhelming number of messages from people watching as far away as Mumbai and Grenada. It was quite an emotional moment. Truly an eclipse for the masses!

ABOUT THE WRITER

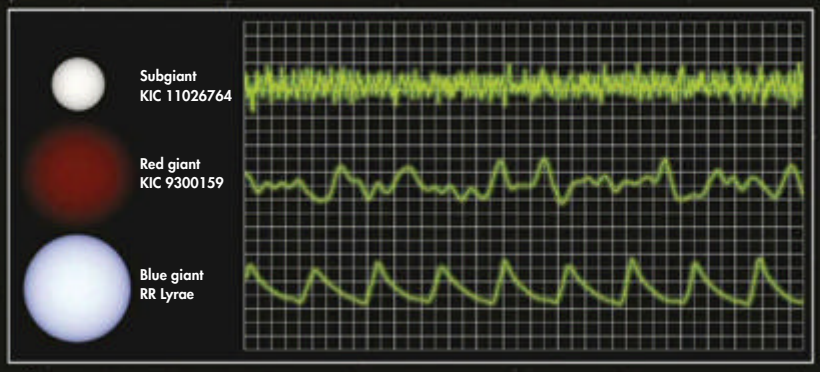
Mark Payne-Gill is a BBC wildlife cameraman who caught the astro imaging bug aged 16. His work has featured regularly on *Stargazing LIVE*.

BENEATH THE SHINING SURFACE

Hidden beneath a gleaming photosphere, the inner workings of stars have long been a mystery. But, writes **Amanda Doyle**, sound waves are allowing us to look at what's going on deep inside our stellar neighbours

ABOUT THE WRITER

Amanda Doyle is a postdoctoral researcher at the University of Warwick. She is also a freelance writer and assistant editor of *Popular Astronomy* magazine.



▲ While some variable stars have predictable light curves, others can be much more chaotic – a result of different acoustic waves altering the star's brightness at the same time

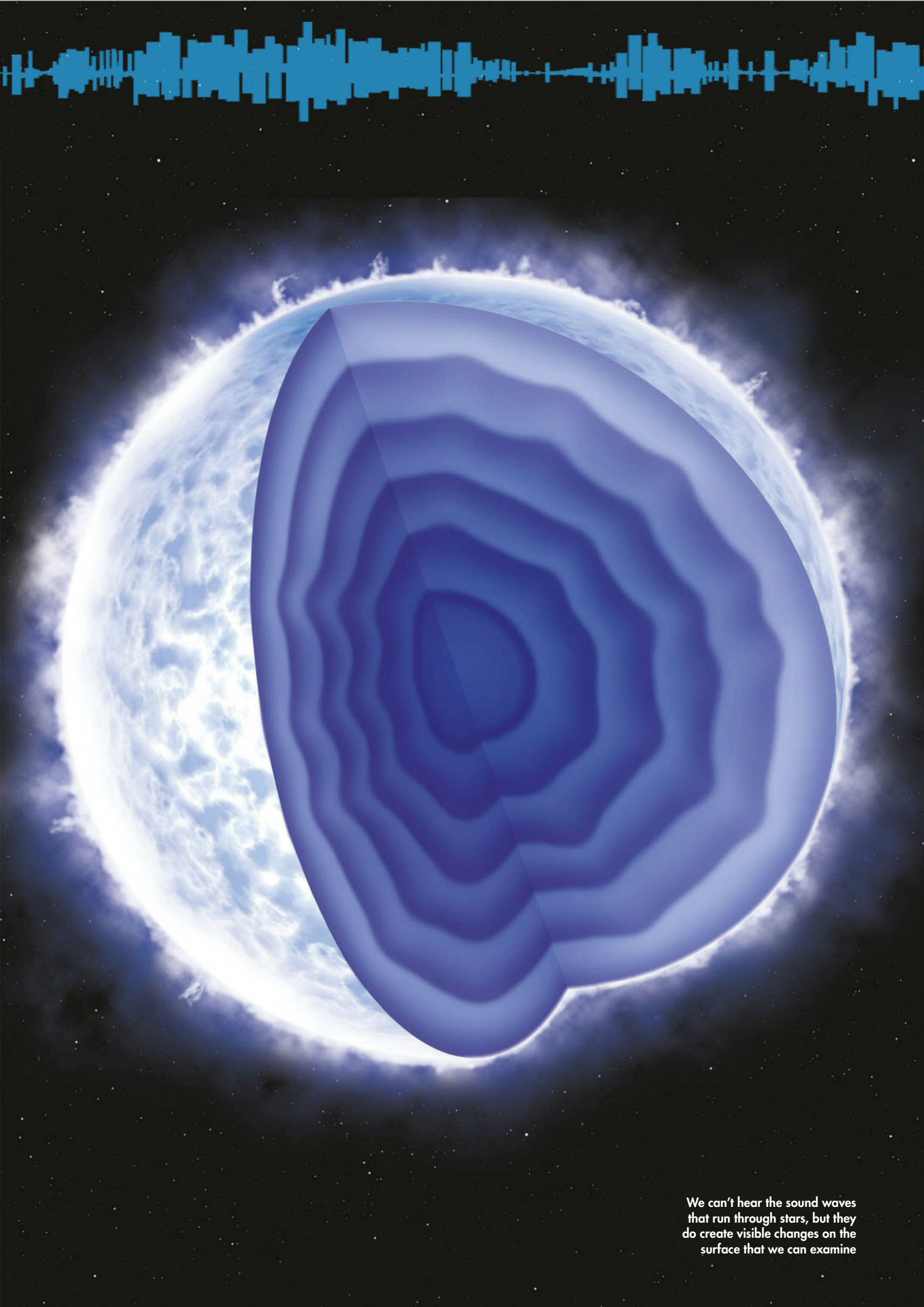
The seismic waves that barge through Earth's interior as the result of a quake carry more than just energy. They also carry information. As these waves travel at different speeds through different materials, seismologists can use them to effectively peel back the layers of our planet to see what is going on deep in its interior. The same principle can also be applied to stars and this study – of sound waves rumbling through stellar interiors – is called asteroseismology. NASA's Kepler mission has revolutionised the field by using this cosmic echolocation to peer inside thousands of stars.

The inside of a star is a noisy place to be, as many stars hum songs to themselves. We can't hear these songs directly because the sound waves cannot escape the star, but they do create a visible effect on the surface. Sound waves continuously bouncing around inside a star cause it to swell and contract, and these movements cause changes in the temperature at the surface, which can be detected as variations in the brightness of a star.

All stars have a pattern of brightness that changes over time, known as a light curve, but if there are numerous sound waves at once this pattern can become crowded and difficult to analyse. A mathematical technique known as a Fourier transform can be used to pluck the individual frequencies out of the light curve. By measuring characteristics such as the spacing between frequencies, it is possible to learn a lot about the star such as its mass, size, and age.

Kepler stared at the same patch of sky for four years, which is crucial for detecting some ▸

NASA, ISTOCK, MAIN ILLUSTRATION BY PAUL WOOTTON



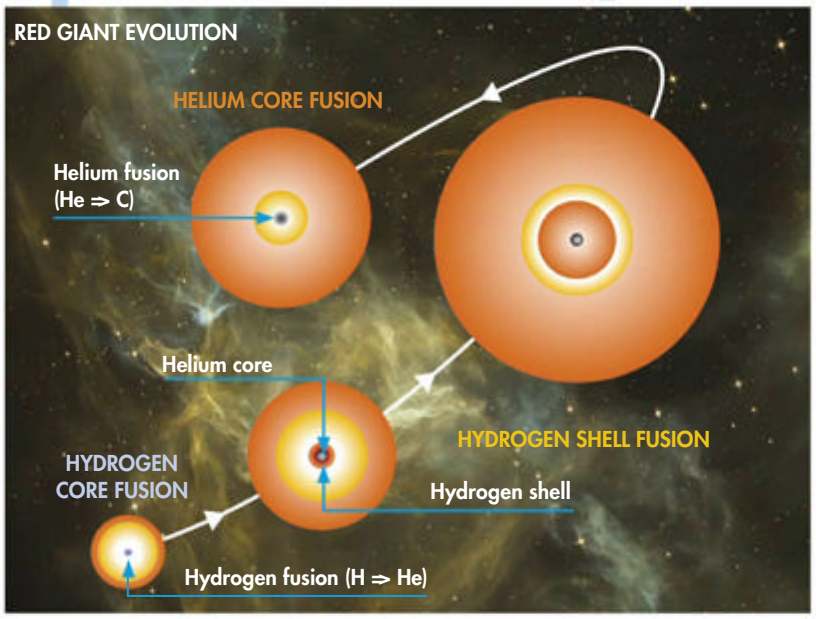
We can't hear the sound waves that run through stars, but they do create visible changes on the surface that we can examine

▸ of the 'quieter' sound waves. While the primary aim of the Kepler mission is to search for exoplanets, the lengthy observations needed to find planets are also perfect for picking out the subtle frequencies in hundreds of pulsating Sun-like stars. "This is opening the possibility to perform detailed studies of the evolution and internal structure of stars like the Sun", says Bill Chaplin of the University of Birmingham.

Stellar lookalikes

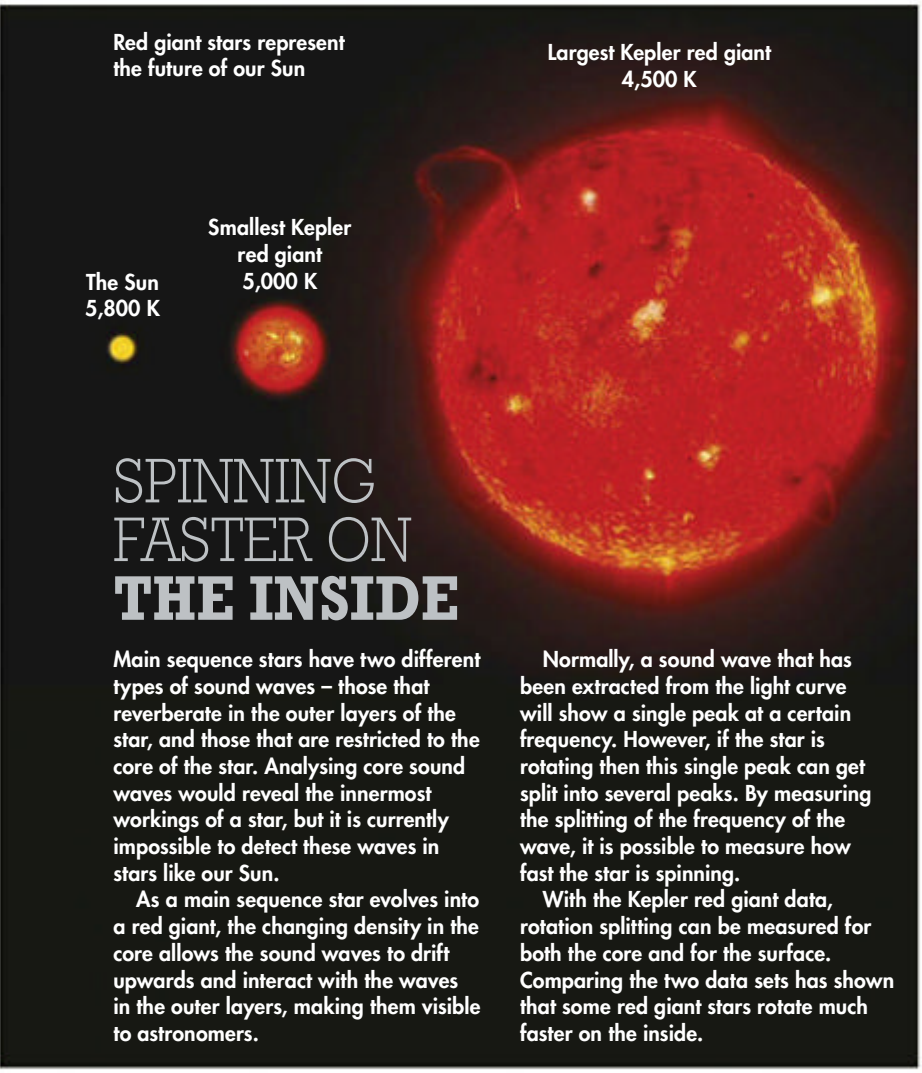
These pulsations are much easier to detect in red giant stars than those less advanced in the stellar life cycle because the periods of the sound waves in red giants are much longer. Younger stars have periods of only a few minutes, whereas a sound wave in a red giant will take hours to oscillate back and forth. A few hundred red giants had measurable pulsations prior to Kepler, and now with the satellite's observations the number of stars has soared to over 10,000.

The interiors of red giants change dramatically as they evolve further. Having exhausted their supply of hydrogen in the core, red giants burn hydrogen in a shell around a dead core. The core eventually reignites, this time burning helium. In both cases the red giant looks the same on the surface – but Kepler has shown that the asteroseismic signatures are very different. Distinguishing the two populations of red giants is a leap forward in our understanding of stellar evolution.



▲ **Red giants at different stages of life may appear the same outwardly, but they differ internally**

STELLAR EVOLUTION ILLUSTRATION: THOMAS KALLINGER/UNIVERSITY OF BRITISH COLUMBIA AND UNIVERSITY OF VIENNA, HERTZSPRUNG RUSSELL ILLUSTRATION: ESO/STEVE MARSH, STARS LIKE OUR SUN ILLUSTRATION: PAUL WOOTTON, BALL AEROSPACE, ESO, ISTOCK X 2



SPINNING FASTER ON THE INSIDE

Main sequence stars have two different types of sound waves – those that reverberate in the outer layers of the star, and those that are restricted to the core of the star. Analysing core sound waves would reveal the innermost workings of a star, but it is currently impossible to detect these waves in stars like our Sun.

As a main sequence star evolves into a red giant, the changing density in the core allows the sound waves to drift upwards and interact with the waves in the outer layers, making them visible to astronomers.

Normally, a sound wave that has been extracted from the light curve will show a single peak at a certain frequency. However, if the star is rotating then this single peak can get split into several peaks. By measuring the splitting of the frequency of the wave, it is possible to measure how fast the star is spinning.

With the Kepler red giant data, rotation splitting can be measured for both the core and for the surface. Comparing the two data sets has shown that some red giant stars rotate much faster on the inside.

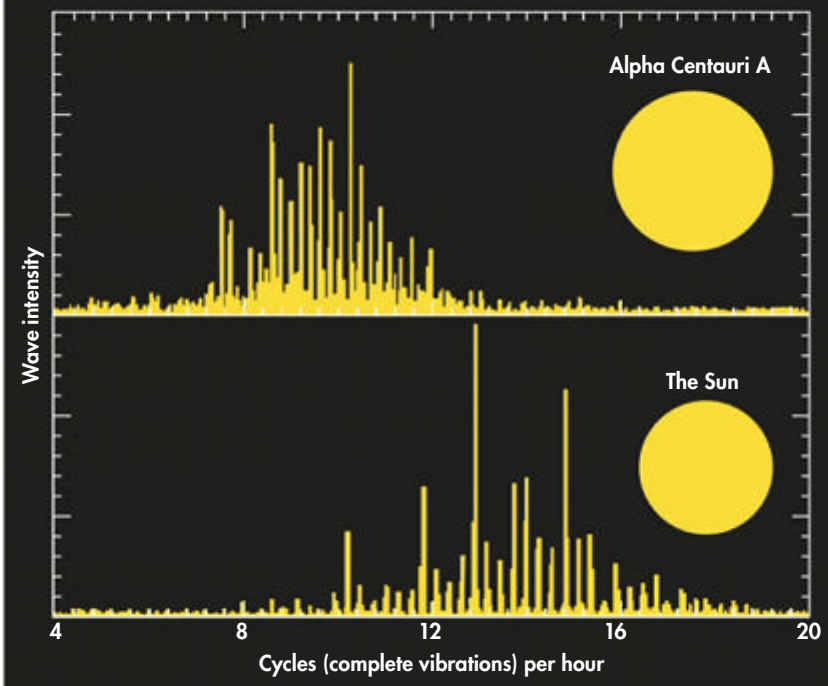
Stellar insights

Delta Scuti variables and Gamma Doradus variables are types of main sequence star that have distinctive pulsation periods. Both classes are hotter than the Sun, and typically Delta Scuti stars have higher temperatures than Gamma Doradus stars. The different temperature ranges mean that these stars sit within their own region on the Hertzsprung-Russell diagram, which is widely used to compare the temperature and brightness of stars in order to track their evolution. Theory predicts that there should be a handful of 'hybrid' stars in the overlap area between the Delta Scuti and Gamma Doradus classes, and that these hybrids will show both types of pulsations.

It therefore came as a surprise when Kepler revealed hundreds of hybrid stars that were littered across both the Delta Scuti and Gamma Doradus regions of the Hertzsprung-Russell diagram. In addition, some stars which should show pulsations remain mysteriously quiet.

Another curious discovery made by Kepler was unusual double periods in RR Lyrae variables. These typically have pulsation periods of around half a day, but some of them also exhibit a longer period where the overall shape of the light curve changes on timescales between tens to hundreds of days, which is known as the Blazhko effect.

Kepler data has revealed that the sound waves in some of these stars can vary on short timescales or on long timescales, and alternate between the two, an effect known as 'period doubling'. Period doubling is known to occur in other types of variable stars, but was never seen in RR Lyrae stars prior to Kepler. Strangely, period doubling only occurs in stars that also



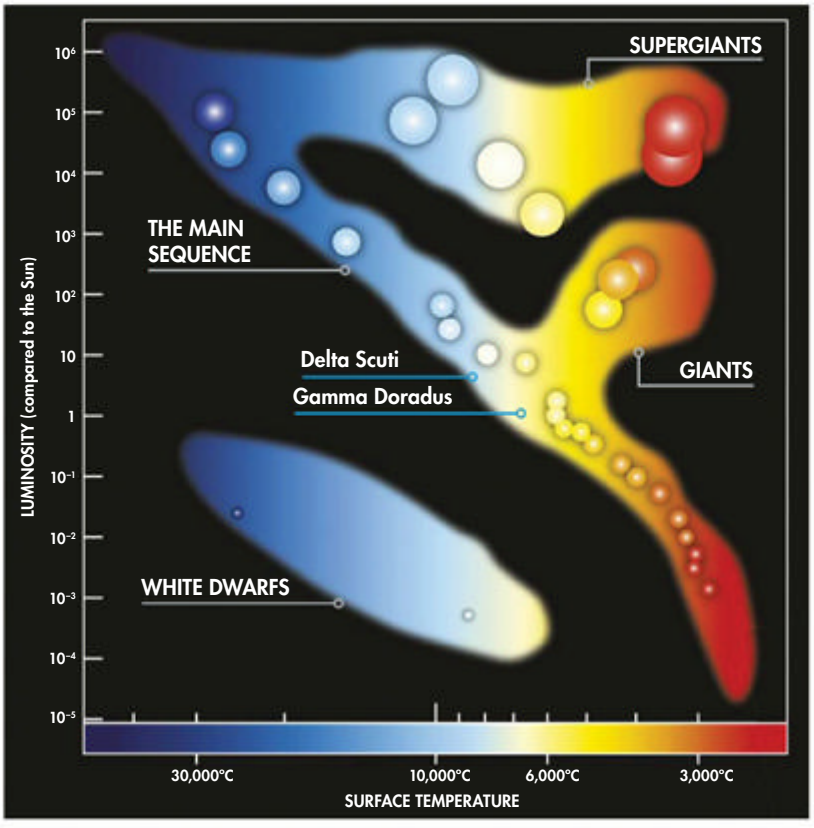
▲ Fourier transforms can be used to infer characteristics such as a star's size and mass

STARS LIKE **OUR SUN**

Studying oscillations in our Sun, known as helioseismology, began in 1962, and having decades of data on the Sun has revealed much about our star. For example, some pulsation frequencies vary with the 11-year activity cycle.

Helioseismology has paved the way for asteroseismology. While the disc of the Sun can be resolved, observing the Sun as if it were a distant point source has ensured that the knowledge gained through helioseismology can be exploited when looking at other Sun-like stars.

The Kepler mission measured oscillations in over 500 Sun-like stars, deciphering parameters such as mass, radius and age. Before Kepler, only around 20 stars had measured pulsations. The stellar parameters from asteroseismology are generally measured to unprecedented precision, which is of particular importance for stars that host exoplanets, and thus tie in nicely with the main objective of the Kepler mission. Without knowing the details of the host star, it is impossible to pinpoint the planet's properties. For instance, knowing the mass and radius of the planet will help to reveal if it is comprised of dense iron or porous rock.



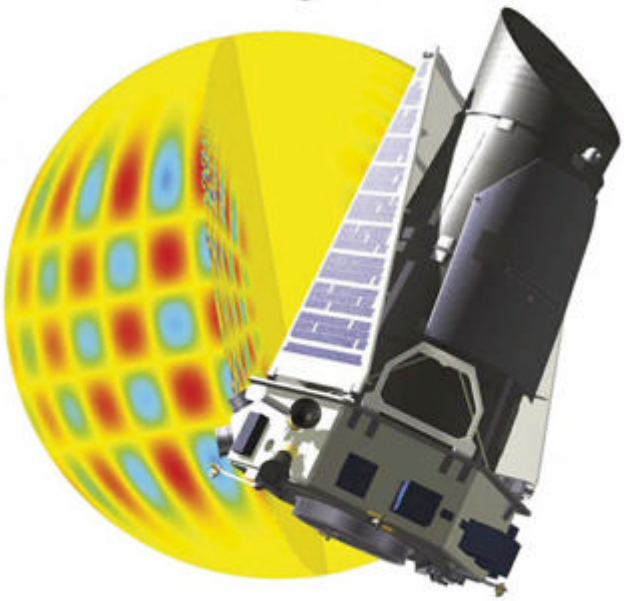
▲ The Hertzsprung-Russell diagram gives us insights into how stars evolve

exhibit the Blazhko effect, indicating a connection between the two types of periods.

The Kepler mission played a vital role in these discoveries and the field of asteroseismology, but in 2013 two of the telescope's reaction wheels failed and it looked like the mission was at an end. However, it was rebooted as K2, which observes different fields for around 80 days each. Asteroseismology needs lengthy observations for the utmost precision, and there is still plenty that can be achieved with K2.

The K2 Galactic Archaeology Programme is surveying red giants over a large proportion of the Galaxy. "In essence what we do is to use the stars as probes of the Galaxy's structure and we use the stellar ages as the clock to obtain a picture of how the Milky Way evolved over its 13 billion-year history," explains Dennis Stello of the University of Sydney, who analyses K2 data as part of his work in the Stellar Oscillations Group at the University of Sydney. Stars like our Sun can also still be studied, and the necessity of observing brighter stars means that information will be available on those stars from other ground-based observational methods, allowing for better characterisation.

K2 is set to continue up until 2017 and will no doubt reveal much more about what really goes on beneath stellar surfaces.



► Kepler will continue to examine how sound waves resonate within stars in the K2 mission

SKILLS

Brush up on your astronomy prowess with our team of experts

The Guide

The oceans of the Solar System

With **Kev Lochun**

Great seas almost certainly exist on other worlds – we just can't see them

Just how special is our Blue Planet? It's a question that continues to vex astronomers as they scour the cosmos for habitats that might support life. Certainly among the worlds within our Solar System, Earth has one feature that clearly stands out, and there's a clue residing within the 'Blue Planet' sobriquet – ours is the only one to have a surface covered in liquid water.

Prior to the space probes of the 1960s, it was thought that Mars and Venus shared in this aquatic accolade, that the Red Planet had canals and that a tropical paradise lurked beneath the dense clouds of 'Earth's twin'. By the middle of that decade both had been proved to be wishful thinking, and though there is evidence that water once flowed on each of them – much more so for Mars than for Venus – whatever surface seas might have existed are now long gone.

Water is, nonetheless, surprisingly common throughout the Solar System: as ice, as gas, possibly even in a 'supercritical' state. For decades our cosmic backyard appeared to mimic that of the most famous lines from the *Rime of Ancient Mariner*: 'Water water everywhere, nor any drop to drink'. Water in abundance, it seemed, except as a liquid, the form essential for life as we know it.

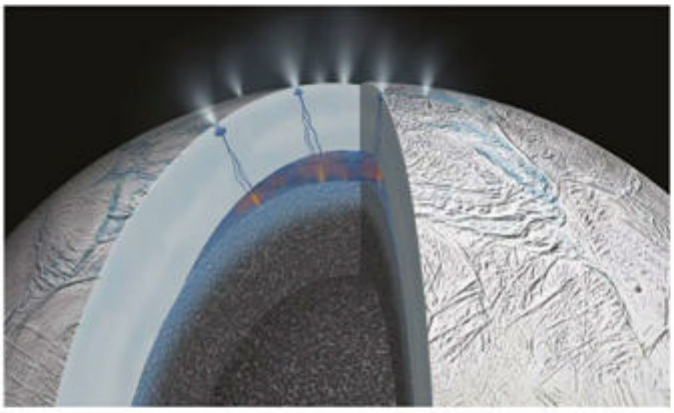
But now we're uncovering increasing evidence that there may be oceans out there after all, not at surface level, but gently sloshing just below the crusts of a handful of dwarf planets and moons. The most famous candidates are on Europa and Enceladus, but there are at least nine worlds that could have subsurface seas within exploring distance.

The marvel of sending rovers to other worlds is only a first step then. If our theories are correct, we are going to need submarines. S

Kev Lochun is *BBC Sky at Night Magazine's* production editor

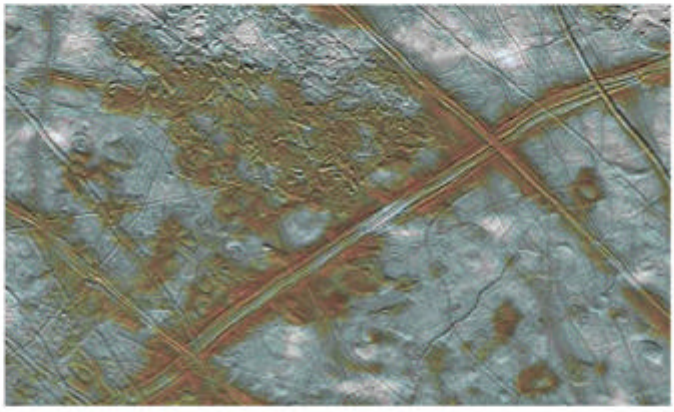
▲ Venus and Mars were once thought to be lush worlds with an abundance of water; sadly we were to find them barren and uninhabited

Our Blue Planet is the only one in the Solar System with water oceans on the surface, but there may be more hiding under the crusts of other worlds



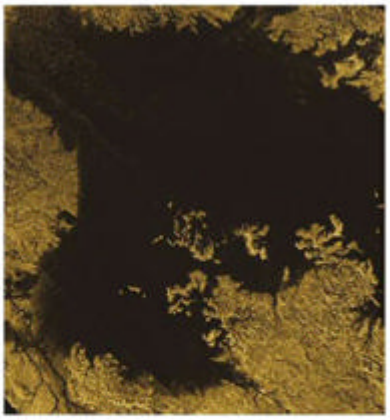
△ ENCELADUS

This Saturnian moon is famed for its giant geysers, the jets of water vapour that erupt into space through a set of 'tiger stripe' fractures near its south pole. Since their discovery in 2005, we've learnt that the water is salty, that the jets contain a smattering of organic compounds, and that the material unleashed feeds Saturn's E-Ring. Gravitational anomalies have also led scientists to believe there is a 10km-deep ocean in this region, and that it could be larger than the greatest of North America's Great Lakes. Moreover, it is thought to be warm and in direct contact with the underlying silicate rock, meaning that it could contain the essential compounds needed for life to thrive.



△ EUROPA

Though primarily rocky, the smallest Galilean moon is also believed to have a global saltwater ocean beneath its icy crust, again in direct contact with mineral-rich rock. Jupiter exerts strong tidal forces on Europa, and these are thought to both generate the heat that prevents the ocean from freezing solid and flex the icy crust to the point that it splinters, creating the long cracks that streak across the moon's surface. It has also been suggested that the dark material that coats these fissures could be sea salt that has been discoloured by radiation. In late 2013, plumes of water vapour were detected around the south pole, prompting a flurry of excitement, but so far it seems to have been a one-off occurrence.



◁ TITAN

Saturn's largest Moon is already famous for its lakes, albeit ones of methane, but it may also have a global underground ocean as salty as the Dead Sea. Unlike Europa and Enceladus, however, astronomers think that Titan's ocean sits above another layer of ice. Variations in the thickness of Titan's icy crust suggest the briny body beneath may be in the process of freezing.

◁ GANYMEDE

The latest (and strongest) evidence for a subsurface ocean on Ganymede comes from an unlikely source: discrepancies in the way the Jovian moon's aurora 'rocks' in response to magnetic fields. The global saltwater ocean inferred to exist as a result is likely to be huge, containing more water than exists on Earth's surface. It is possible this ocean is arranged as a 'sandwich' of several layers of water interspersed with seams of ice.

Triton is a complex moon, with terrain that looks to have been shaped by tectonics and geysers thought to spew out nitrogen

THE SUSPECT SEAS

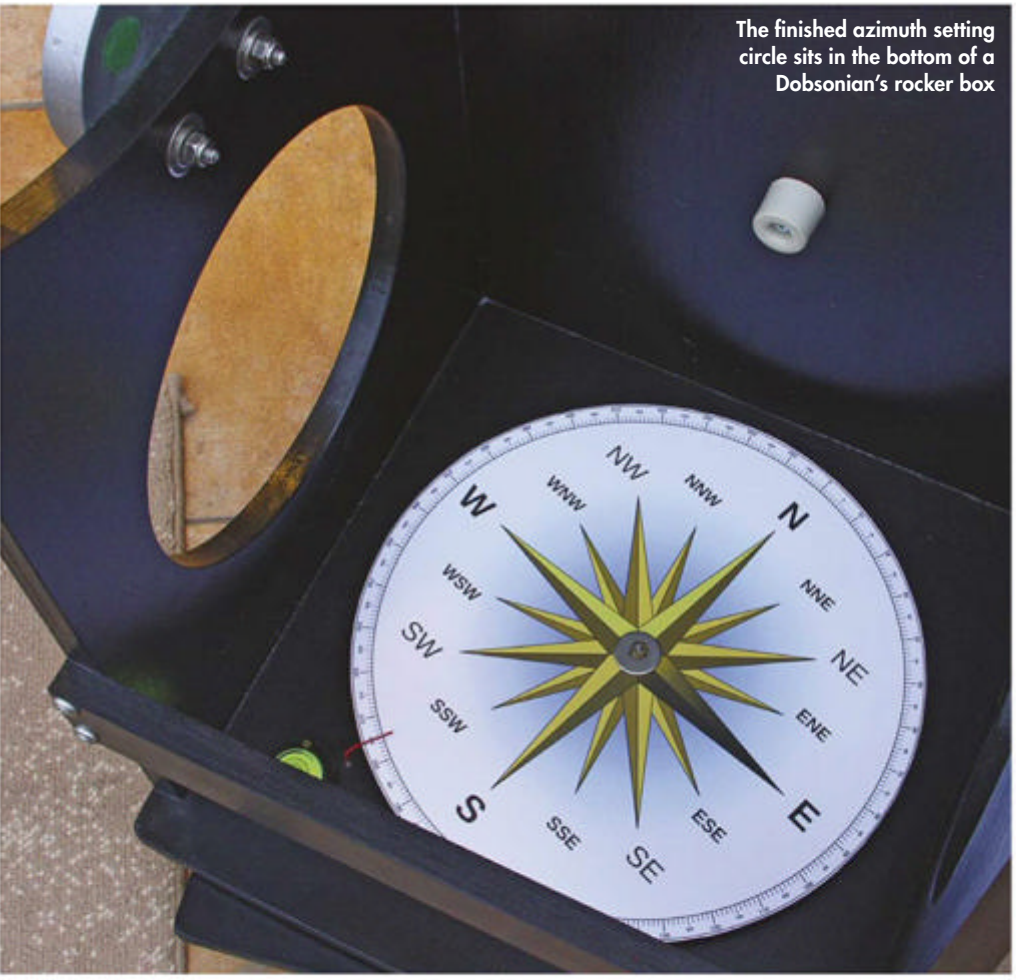
Five more worlds could possibly possess underground oceans. Electrical currents detected by the Galileo probe suggest that cratered Callisto may be the third Galilean moon where life could exist; a saltwater ocean could act as the conductor. Saturn's 'Death Star' moon Mimas shows a unusual wobble in its orbit – too large for its diminutive stature – that could be caused by a hidden body of water. The final candidate moon is Neptune's largest, Triton, which is thought to be a captured Kuiper Belt object. It's possible that the huge gravitational forces Triton would have sustained on its capture could have resulted in an ocean.

The final two are dwarf planets we hope to find out more about very soon: Pluto, the case for which centres on the theory that it once sustained a significant collision, and Ceres, which could be as much as 25 per cent water-ice and hold the remnant of an ocean. The Dawn spacecraft is already at Ceres, and New Horizons is due to arrive at Pluto this month, so we may not have to wait too long.

How to
Make an azimuth setting circle

With **Steve Richards**

A simple project to help you to locate targets with a Dobsonian



The finished azimuth setting circle sits in the bottom of a Dobsonian's rocker box

ALL PICTURES: STEVE RICHARDS

The Dobsonian mount is well known for its simplicity of use: locate an object by star-hopping to it and then give the mount a gentle nudge every minute or so to keep it within the view of your eyepiece. However, many deep-sky objects can be rather difficult to find as they are so dim that they can't be seen in your finderscope. The use of setting circles can make this task a little simpler by allowing you to point accurately to anywhere in the night sky.

Although the RA and dec. coordinates of almost all celestial objects visible to amateur astronomers are readily available, they can't be used with an altaz mount such as a Dobsonian. Altaz mounts instead rely on altitude (degrees above the horizon) and azimuth (degrees clockwise from due north). And, unlike RA and dec., the altitude and azimuth of a celestial object constantly change with the movement of the sky overhead. This constant shifting means that, with an altaz mount, you will need to refer to a planetarium program to find the positions of objects you want to see through the eyepiece.

Breaking convention

Let's say you known the position of the object you want to observe. The altitude of the telescope can easily be set by using an electronic inclinometer, but for the azimuth a calibrated 360° setting circle is required. Conventionally, this would be installed on the baseboard and read through a peephole in the base of the rocker box. In our design, we make use of the fixed azimuth bearing bolt that is attached to the baseboard. This bolt has an Allen key cap and the azimuth setting circle simply presses into the hexagonal cut-out in the head. You can download a template for this setting circle – as well as other files related to this project – from **http://bit.ly/howto122**. We'd recommend printing the setting circle on card and then giving it a matt lamination, as this will reduce any reflections that would make the

TOOLS AND **MATERIALS**

ELECTRONICS
A digital inclinometer – various makes are available, including Wixey, Minipro, Bevelbox and Digi-Pas.

MATERIALS
A vinyl record to act as a 'table' for the setting circle. Ask a local printer to reproduce the setting circle on card and laminate it.

SUNDRIES
A 2BA x ½-inch bolt, two 2BA nuts, two penny washers and a small section of silicone vacuum hose are required to complete the assembly; you'll also need a paperclip and epoxy resin to fashion a pointer.

TOOLS
Hand file and bench vice to modify the mounting bolt, scissors and craft knife to trim the setting circle template, and a hand drill to create the hole for the pointer.

▲ Once installed, you'll be able to align your Dobsonian to the desired azimuth with ease

scale difficult to read. We also used a vinyl record to support the card.

Your first task is to modify the hexagonal head of a 2BA bolt by filing each of its six sides evenly until it is an interference fit (ie, it holds by friction) inside the head of an M10 azimuth bearing bolt. Hold the bolt head (not the thread) in a small vice and file each side in turn. To make a firm but adjustable bearing to support the vinyl record, cut a 2mm ring from a length of silicone vacuum hose and press it into the centre of the LP.

Finding your position

Cut a 5mm hole in the centre of the azimuth circle and then assemble the unit with the modified 2BA bolt, 2-inch M6 penny washer, vinyl record, setting circle template, 1-inch M6 penny washer and two 2BA nuts as shown in the Assembly Diagram available to download from **http://bit.ly/howto122**. Tighten the 2BA nuts against one another to lock them.

It is not always possible to arrange for the mount's baseboard to be correctly orientated to north so we have designed the azimuth setting circle to allow for simple calibration. First, point the telescope at Polaris (nominally 0°) or centre a known star in the eyepiece. Then rotate the setting circle until the pointer aligns with the star's azimuth. The scope can then be set to any azimuth by rotating the rocker box until the pointer aligns with the required angle.

The telescope's altitude angle can be set by placing the digital inclinometer on the rocker box base and setting it to zero then placing it on the telescope and adjusting the telescope to read the correct angle.

Steve Richards is a keen astro imager and astronomy equipment expert

PROJECT RESOURCES

Download templates to accompany this project at **http://bit.ly/howto122**

STEP-BY-STEP GUIDE

STEP 1

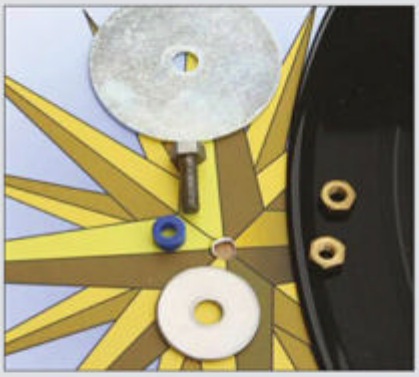
Ask a local digital printing company to reproduce the azimuth setting circle template available through the link below on stiff matt card and have both sides laminated with a matt finish. Carefully cut around the perimeter with scissors.

STEP 2

File down the head of a 2BA x ½-inch hex bolt by holding the bolt's head in a bench vice, making sure that all six sides are evenly reduced. File until it is an interference fit in the M10 Allen key cap head on top of the bolt that forms the azimuth bearing of the mount.

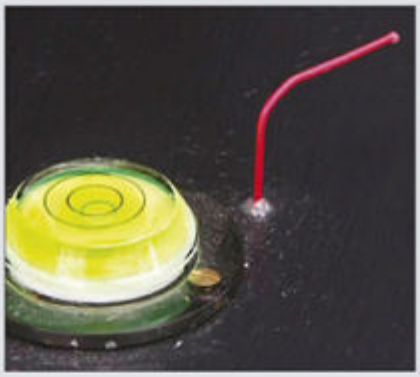
STEP 3

Cut a 2mm section of silicone vacuum hose to form a small ring – this will be a carrier to firmly support the azimuth setting circle while allowing rotational adjustments to be made for calibration. Carefully insert this ring into the centre of the LP prior to final assembly.



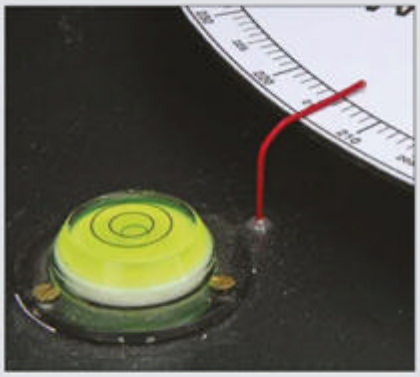
STEP 4

Assemble the setting circle using the modified 2BA x ½-inch hex bolt, 2-inch penny washer, vinyl record, azimuth setting circle, 1-inch penny washer and two nuts to match our Assembly Diagram. Tighten the first nut to gently grip the assembly then lock it with the second nut.



STEP 5

Place the completed setting circle onto the azimuth bearing bolt and drill a 1mm hole into the rocker box base near the edge of the circle. Bend a right angle in the plastic coated paper clip to form a pointer and insert it into the hole, its end smeared with epoxy resin.



STEP 6

Level the mount using the adjustable feet. Locate Polaris or a known star in the centre of your eyepiece, look up its current azimuth and rotate the setting circle until this figure lies directly under the pointer. The setting circle is now calibrated.

Image processing

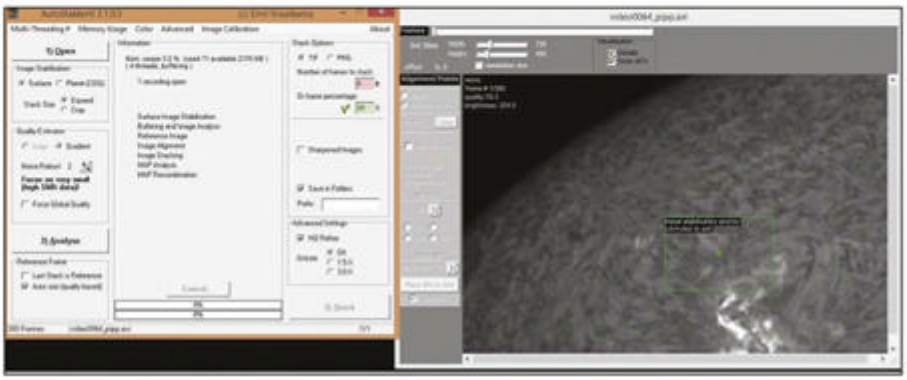
Solar mosaics: stacking PART 1

With **Gary Palmer**

Creating a solar mosaic image can reveal a lot of detail that you wouldn't achieve in a single full-disc capture of our star. They are fun to create but can be time consuming to produce, so we are going to use an automated sequence in Photoshop to help speed up the process. In the first of this two-part tutorial we are going to look at processing the images ready for Photoshop.

There are two things to remember when recording your initial video files: your images need to have a good overlap for Photoshop's script process to work, and your camera needs to be positioned to run horizontally across the solar disc, not diagonally, as it will help to ensure there are no gaps.

Gary Palmer is an expert solar imager. See more of his shots at www.solarsystemimaging.co.uk

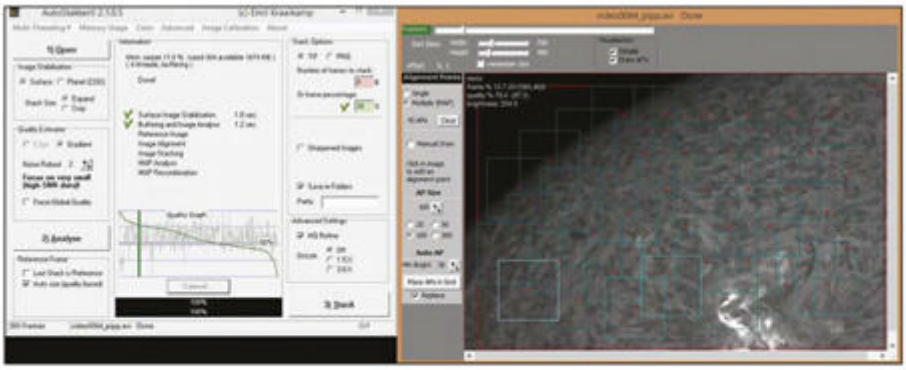


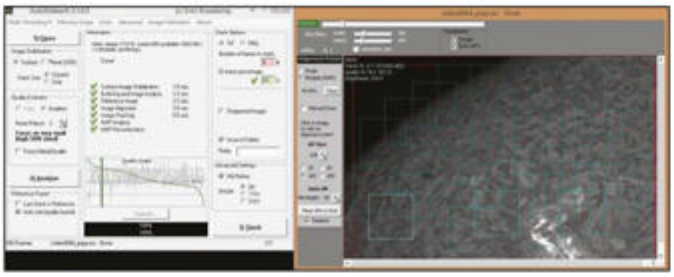
◁ STEP 1

We are going to start by running all of the video files through AutoStakkert!2 to create single frames. Click on the Open tab on the main page and load one of the video files. Now, in the Image Stabilization area, click the Surface and Expand check boxes. Next is the Quality Estimator area. If the seeing conditions were good, use a figure of 2; if they were poor then 3 or 4 would be better as this will result in less noise when AutoStakkert! analyses the image. Leave all the other settings as standard.

STEP 2 ▷

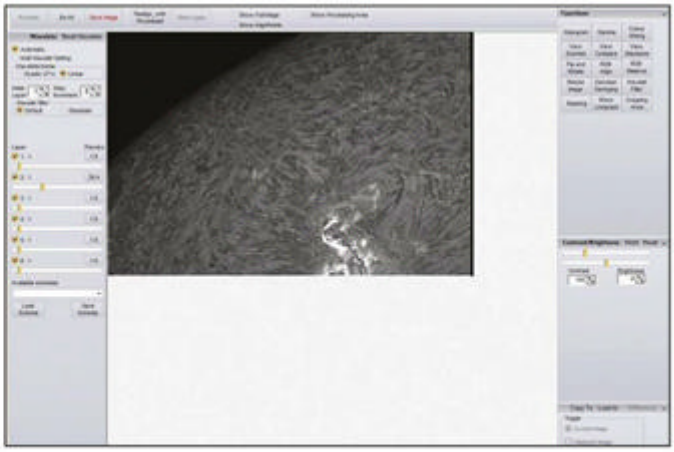
Now turn to the Frame viewing window. Hold Ctrl and click in the centre of the image to set the Image Stabilisation Anchor. At the top of the screen, adjust the frames slider to display one of your good frames. Click Analyse on the main screen. Once complete, you will see a graph representing frame quality appear. You now need to select the number or percentage of frames to stack under the Stack Options; 30 per cent is a good amount to start with. Back in the Frame window, set the AP size to 100 and click Place AP Grid.





◁ STEP 3

Finally, back on the main window, click Stack. The files will be saved in the source location; you will need to repeat this process for all of your video files and to keep the settings the same for each file.



STEP 4 ▷

The last step of this part is to use RegiStax 6 to gently sharpen the frames, as this will help Photoshop to auto align the images. You can drag and drop your picture from its source directory into RegiStax; it will then open the Wavelet adjustment page. There is a control panel in the upper left: set the Wavelets Scheme to Linear and the Wavelet Filter to Default. Below this are a set of sliders, and you need to drag the second to about 40.0. This is flexible; what you are watching out for is that you don't introduce noise. When you are happy with your tweaking, click Do All and then Save. If your computer is on the slow side opt for jpeg instead of tiff; this speeds up the process in Photoshop. Repeat for each image.

ALL PICTURES: GARY PALMER

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Scope DOCTOR

With **Steve Richards**

Our resident equipment specialist cures your optical ailments and technical maladies

The Mallincam range of cameras are among those that can be used to stream celestial sights live

I want to buy a camera to stream live video from my 6-inch, f/8 Sky-Watcher refractor and my 5-inch short tube refractor. What can you suggest in the £150-£300 range?

TERRY LESTER

A live streaming video camera is a great way to share the night sky with other people, and watching images of the Moon, planets and brighter deep-sky objects comfortably on a video screen always produces that special wow factor. A video camera will collect and display more light than your eye alone can see, so many deep-sky objects will come alive when viewed this way. As a bonus, as well as viewing the objects in real time, you can also save the images to your computer for further processing using a suitable 'video grabber' adaptor.

There are several cameras available in your price range, but the first choice that you must make is whether you want colour or monochrome – the former adds something extra for your audience, but the latter offers greater sensitivity.

The lowest priced colour option is the Mallincam Micro-Super at $179.99 for a complete outfit. However, the very popular Phil Dyer PD colour video camera can be bought in the UK with all cables, power supply and even a video grabber for under £200.

For increased sensitivity, you really need to turn to a monochrome sensor. Just at the top of your budget is the Mintron 22S85HC-EX mono camera kit. To better this performance you will have to exceed your budget, but it would be worth considering the Mallincam Junior Pro mono camera at $599 or the colour version for an extra $100.

WWW.THESECRETSTUDIO.NET, PAUL WHITFIELD

STEVE'S TOP TIP

Do you have any advice for observing the Sun safely?

The Sun is a truly fascinating object to observe but the utmost care must be taken to observe it safely to avoid irreparable damage to your eyes.

The safest method is to observe using a special solar telescope designed solely for this purpose, which incorporates specific hydrogen-alpha and energy rejection filters. However, a normal telescope can also be used safely providing a filter made from Baader AstroSolar Safety Film is firmly attached to the front of the telescope. Never consider using any filter that attaches to the eyepiece as these can be extremely dangerous. Always remove your finderscope completely.

Transportability aside, what differences are there between Dobsonian and Schmidt-Cassegrain telescopes of the same aperture for observation and astrophotography?

CHRISTOPHER HARRIS

An SCT's focal length makes it ideal for planetary imaging

A Dobsonian telescope is simply a Newtonian reflector mounted on a basic altaz platform that you move by hand. The difference between a Newtonian reflector and a Schmidt-Cassegrain of the same aperture is that despite the latter having a much shorter physical tube length, it has a much greater apparent focal length. Typical focal lengths for 10-inch aperture telescopes are 1,250mm for a Newtonian and 2,500mm for a Schmidt-Cassegrain.

The significance of this is that for any given eyepiece, the Schmidt-Cassegrain will give a 2x greater magnification than a Newtonian. For observing, a Schmidt-Cassegrain is best suited to Solar System objects, planetary nebulae, galaxies and double stars whereas a Newtonian is more of a general-purpose instrument. However, a Newtonian is more suitable for deep-sky imaging as it is less challenging for tracking the mount and it suffers considerably less from 'mirror flop', a condition prevalent in Schmidt-Cassegrains where the mirror moves slightly whilst traversing the sky.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

★★★★★ Outstanding
★★★★½ Very good
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor/Avoid

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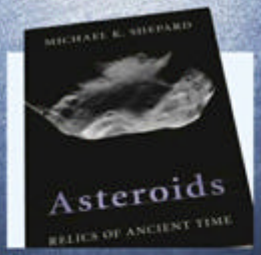
82

Find out why these 16x70 binoculars are worth getting excited about

This month's reviews



First light

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96 Including this meteorite-bearing watch

Find out more about how we review equipment at **www.skyatnightmagazine.com/scoring-categories**

FIRST **light**

See an interactive 360° model of these binos at **www.skyatnightmagazine.com/Echelon16x70**

Celestron Echelon 16x70 binoculars

Eye relief, good balance and anti-dew measures make these binos worth a look

WORDS: STEPHEN TONKIN

VITAL STATS

- **Price** £849
- **Optics** XLT coatings (fully multicoated)
- **Aperture** 70mm
- **Magnification** 16x
- **Exit Pupil** 4.4mm
- **Prisms** BaK-4 Porro prisms
- **Angular field of view** 3.8°
- **Focusing** Individual eyepiece focus
- **Eye relief** 18.6mm
- **Interpupillary distance** 58-72mm
- **Weight** 1.85kg
- **Supplier** David Hinds
- **www.**celestron.uk.com
- **Tel** 01525 852696

WWW.THESECRETSTUDIO.NET X 5

Binoculars with 70mm apertures represent a substantial step up in light-gathering potential compared to handhelds with only 40mm or 50mm apertures, so when we heard about Celestron's Echelon 16x70s –aimed at the quality end of the 70mm market – we were very keen to try them out.

The binoculars come in a rugged plastic case and are supplied with a padded neck strap, individual objective lens caps, a tethered rainguard-type eyepiece cover, microfibre cleaning cloth and an instruction leaflet that is generic to the Echelon range. The body is aluminium alloy covered with textured rubber. The hinge moves smoothly, with enough resistance to make it easy to adjust but not liable to sag when the binoculars are mounted.

Individual eyepiece focusing is very smooth but not as stiff as the hinge, making it easy to focus without affecting the interpupillary distance. The minimum interpupillary distance is 58mm, but whether this is attainable in practice will depend upon the geometry of your face because at this distance there is only 8mm between the eyepieces. The eyepiece cover limits the interpupillary distance to 62mm, so if your eyes are wider apart you will need to adjust the binoculars every time you uncover the eyepieces.

SKY SAYS...
We saw good contrast on the lunar terminator, suggesting effective control of stray light

We measured the exit pupils and found them to be almost exactly 4mm. At 16x magnification, this is inconsistent with an aperture of 70mm, and on investigation we found that although the physical aperture is 70mm the light path is internally stopped, giving an effective aperture of about 65mm. The aim of this is usually to reduce optical aberrations and give crisper, if slightly less bright, images. We also noticed a tiny pair of dark segments at the periphery of each exit pupil, suggesting slightly undersized prisms, but these had an imperceptible impact on image quality – which overall was very good.

The eyecups are made from a comfortable soft rubber and, folded up, permit the full 3.8° field of view to be seen. The 18.6mm eye relief enables the full field of view to be visible without pushing the eyepieces against your spectacles when the eyecups are folded down.

Better than budget

For testing, we mounted the Echelon 16x70s on a lightweight parallelogram mount under a good suburban sky. It 'snapped' to a good focus and the images from each side merged properly, showing that collimation was within acceptable tolerances. A small amount of pincushion distortion, which manifests as straight lines at the edge of the field ▸

WELL-IMPLEMENTED ERGONOMICS

The one-piece construction is made from lightweight aluminium alloy, making it much lighter than is usual for binoculars of this size and quality. Coupled with the good weight distribution, the result is an exceptionally well-balanced instrument, and it is possible to hold these binoculars by hand for quick views or when no mount is available. To aid in this, there are smooth elliptical patches on the underside of the prism housing, which can be felt even through thick gloves, to guide your thumbs into the best position for a well-balanced grip. The rubber armour, which is substantial and pliant enough to afford some protection against minor accidental knocks, has a texture that is non-slip even when it is wet with dew. Allied to this, the eye relief is more than adequate, making these binoculars especially useful to people who need spectacles while observing. Meanwhile, the curved neck strap is designed to be comfortable in extended use. The overall result is a pair of binoculars that are extremely pleasant to explore the skies with.

WATERPROOF AND NITROGEN PURGED

Observing in the dewy conditions that are common in the UK brings the risk that humid air will condense inside the binoculars, eventually leading to damaging algal or fungal growth. As the Echelon 16x70s are waterproofed and filled with dry nitrogen, this source of potential damage is effectively eliminated.

MULTICOATINGS

Celestron's proprietary anti-reflective XLT coatings seem to be very good indeed. The minimal amount of reflection that we saw when we examined them under a bright light suggests that they have been properly applied, and confirmed that all the glass-air surfaces are multicoated. In use, we could detect no telltale ghost images from internal reflections.

RECESSED OBJECTIVE LENSES

The objective lenses are recessed 18mm into their barrels, offering some protection against damage, dew and glare. This also means it is less likely that dust will collect on the lenses or that you will accidentally touch them, thereby reducing the frequency with which they need to be cleaned.

FIRST light

RUGGED CASE

The rugged plastic case is padlockable and waterproof, with a non-captive air valve that allows pressure to be equalised after, say, a journey by air. The binoculars are cradled in a cut-out in a single piece of medium-density foam. This provides very good protection for your investment.

SKY SAYS...
Now add these:

1. LensPen optics cleaning tool

2. Celestron Regal tripod

3. Binocular tripod adaptor

NECK STRAP

The neck strap is of far better quality than is usual with binoculars of this class. The padded part is made from 6mm-thick neoprene foam and is 55mm wide. It is also curved so that there are no areas that dig into the skin when the binoculars are suspended from your neck.

▸ of view appearing to curve towards the centre, was present. This distortion was just sufficient to prevent the nausea-inducing 'rolling ball' effect that can occur without it. The on-axis colour correction was very good, although this is somewhat sensitive to eye position.

The constellation of Coma Berenices was well placed at the time of review, so we used Melotte 111 to determine limiting magnitude. The faintest star visible with direct vision was mag. +10.1. We then panned down to the globular cluster M53, which we could see as distinctly non-stellar. We also observed the Moon on several occasions; it showed very good contrast on the terminator, suggesting effective control of stray light.

We used double star Iota Cancri to establish the extent of the sharp field of view: its two components are mag. +4.0 and +6.5, with a separation of 30.5 arcseconds. We found that splitting these stars started to become difficult at 80 per cent out from the centre, and that by 90 per cent we could no longer distinguish Iota Cancri as being a double star at all. During this test, we noticed that the brighter component appeared slightly yellow compared to the fainter one, suggesting very good colour rendition. This was confirmed by the brilliant white of Alderamin (Alpha Cephei) contrasting vividly with the vibrant amber of Herschel's Garnet Star (Mu Cephei), and by the colours of double star Albireo in Cygnus being the distinctive gold and sapphire that you would expect from good optics.

The Echelon 16x70s are an enormous improvement on budget 70mm binoculars and are worth considering by anyone who primarily observes with binoculars, but especially by those who need to wear spectacles while stargazing. S

VERDICT

BUILD & DESIGN	★★★★★
EASE OF USE	★★★★☆
EYE RELIEF	★★★★★
FEATURES	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★½

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FIRST **light**

See an interactive 360° model of this mount at **www.skyatnightmagazine.com/iEQ30Pro**

iOptron iEQ30 Pro German equatorial mount

A smart update that enhances an already proven design

WORDS: PAUL MONEY

VITAL STATS

- **Price** £1,150
- **Mount** Computerised EQ Go-To mount
- **Max capacity** 13.5kg
- **Controller** Go2Nova 8407 hand controller
- **Database** 359,000 objects including the planets, Moon and Sun, and the Messier, NGC and Caldwell catalogues
- **Power requirements** DC 12V (11~15V) 2A
- **Extras** Stainless steel adjustable tripod, 4.5kg counterweight, 12V DC car plug adaptor, stainless steel counterweight shaft, RS232-RJ9 cable
- **Weight** 17kg (mount and tripod)
- **Supplier** Altair Astro
- **www.**altairastro.com
- **Tel** 01263 731505

WWW.THESECRETSTUDIO.NET X 6, PAUL MONEY

Mount-maker iOptron continually refines and updates its most popular mounts, and the latest to get this treatment is the iEQ30, now released as the improved iEQ30 Pro. On the surface it looks almost identical to the original, but inside are ultra-quiet stepper motors and improved electronics, and in performance terms it offers better Go-To and tracking accuracy.

SKY SAYS...
The mount kept the bright star Regulus in the centre of the view for over 30 minutes

The iEQ30 Pro accepts standard Vixen-style mounting bars and has an integrated polarscope with illuminated reticule. It is supplied with the Go2Nova 8407 hand controller, a heavy-duty stainless steel tripod with leg spreader, 4.5kg counterweight, stainless steel counterweight shaft, 12V DC car plug adaptor and a RS232-RJ9 cable so you can connect it to a computer; the mount's RS232 port also allows for firmware updates as well as ASCOM control.

The mount's carrying capacity is up to 13.5kg, making it suitable for use with small and medium telescopes. The combined weight of the mount head and tripod comes to 17kg, so it is relatively portable and could be taken to a site with darker skies. The Go2Nova 8407 hand controller has over 359,000 objects in its database and in-built 32-channel GPS. Within a few minutes of being powered up, it will automatically set your latitude and longitude, time zone, date and time. We were also able to attach our own Wi-Fi controller and operate the mount using our smart tablet – it was nice to have this added flexibility of control.

We found the initial polar alignment process easy as the handset can give a visual representation of where Polaris should be positioned in the illuminated polarscope. The polarscope also has a bubble level fitted, so it was easy to set the mount to its zero configuration, with the scope pointing towards north and set for the north celestial pole. iOptron says that the mount should also be levelled for best performance, however we did note it is not easy to view the bubble level, which is on the base of the mount, as the polarscope axis lies above it.

Skyward bound

For our initial tests we used an Equinox 80ED refractor and a SkyMax 180 Pro Maksutov, which weigh 3kg and 8kg respectively. The SkyMax 180 Pro plus an 80mm guidescope and a Canon EOS 50D DSLR were pressed into service for astrophotography, their combined weight of 12kg coming nicely under the payload limit.

After performing a three-star alignment over a wide area of sky, our selected targets were centred inside the inner 15 per cent of the Equinox 80ED's wide field of view. With the SkyMax 180 Pro and a higher magnification our targets fell within ▸

QUIET AND ACCURATE TRACKING

Many mounts tend to be somewhat noisy in operation, and in the dead of night the last thing you want is kit that wakes up the neighbours. But we were very impressed with how quiet the iEQ30 Pro was, even at high slew rates: when tracking a target we could barely hear it operating.

We were also impressed with how smooth the tracking is – it was only after careful monitoring that we noticed a slight variation in the position of our selected star, as the mount kept it well centred. With the alignment process completed, it was gratifying to see our chosen targets close to the centre of the wide field of view. This can be improved with the addition of more alignment stars, which is especially useful for astrophotography. All this is achieved with the upgraded worm wheels and stepper motors within this mount.

M13 imaged as a stack of 13 one-minute exposures at ISO 2000

ALTITUDE AND AZIMUTH ADJUSTMENT

The altitude and azimuth knobs give fine control over the adjustments required for accurate polar alignment. The altitude adjustment is set at the high latitude range, 25°-65°, while the two azimuth knobs have a range of ±6°.

POLARSCOPE

The in-built polarscope has a detachable illuminated reticule and a bubble level on the outside to help you obtain the correct alignment. The position of Polaris can be determined via the handset or by using the iOptron smartphone polarscope app. Both methods gave good results.

PORTS

Along with the DC 12V power connector and on-off switch, there are also a selection of ports: hand controller (HBX), ST-4 for autoguiding, RS232 for a computer connection, dec. cable, and one to supply power to the polarscope reticule.

FIRST light

TRIPOD

The stainless steel adjustable tripod did a good job and is fitted with a leg spreader. Unusually, the mount body is not attached to the tripod via its central bolt, but via two upper bolts on the mount head itself. The tripod head has a central locating pin.

SKY SAYS...
Now add these:

1. iOptron PowerWeight battery pack

2. iOptron TriPier portable pier

3. iOptron StarFi wireless adaptor plus Commander software

HAND CONTROLLER

The Go2Nova 8407 hand controller has a large, eight-line LCD screen, 359,000 objects in its database and has a range of useful functions, including one to determine where Polaris is. In-built 32-channel GPS means that date, time and location are set automatically.

▸ the inner 25 per cent of the view. Sticking with the Skymax 180 Pro, we focused on the bright star Regulus in Leo – the mount kept the star in the centre of the view for over 30 minutes. Imaging was much more demanding, but we found that we were able to achieve one-minute exposures with no guiding involved. With today's high ISO cameras, there is plenty that can be imaged before you even need to add a guidescope to the system via the integrated ST-4 port.

We also enjoyed the ease of set up with this mount; we found we could be taking a tour of the night sky within 10 or so minutes, and the lightweight nature of the mount lends itself to local travel very well. S

VERDICT	
ASSEMBLY	★★★★½
BUILD & DESIGN	★★★★½
EASE OF USE	★★★★★
TRACKING ACCURACY	★★★★½
STABILITY	★★★★½
OVERALL	★★★★½

FIRST **light**

See an interactive 360° model of this camera at **www.skyatnightmagazine.com/Atik414EX**

Atik 414EX mono CCD camera

Large pixels help this small camera offer up surprising sensitivity

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £1,019
- **Sensor** Sony ICX825
- **Sensor size** 8.9x6.7mm (11mm diagonal)
- **Pixels** 1,392x1,040 pixels (6.45µm square)
- **Readout noise** 5e
- **Backfocus distance** 13mm
- **Extras** 1.25-inch nosepiece with dust cover, 3m USB cable, 1.8m power cable, software CD, desiccant plug removal tool
- **Weight** 381g
- **Supplier** Atik Cameras
- **www.**atik-cameras.com
- **Tel** 01603 740397

WWW.THESECRETSTUDIO.NET X 4; STEVE RICHARDS

There is always an element of excitement among astrophotographers when a new camera is released, and the arrival of Atik's 414EX CCD is no exception. Astro imagers constantly look for increased sensitivity and larger sensors, and this one claims to meet the first head on. Monochrome and colour variants of this camera are available – it is the former we are reviewing here.

SKY SAYS...
The Atik 414EX was quick to setup and begin imaging, and was very sensitive indeed

The 414EX is attractively finished in a high-gloss electric red with contrasting black trim. There are minimal connections at the rear of the cylindrical alloy casing – just a 12V power input and a USB Mini B socket. Included in the box are a 1.25-inch nosepiece with dust cover, 3m USB cable, 1.8m cigar lighter power cable, software CD, a tool to remove the desiccant plug and an instruction manual.

The software was quick and simple to load, and immediately recognised the camera. We carried out a set of test images using the supplied Artemis image capture software to confirm that the camera was functioning properly, but for our real imaging sessions we used the supplied ASCOM driver and controlled the camera via MaxIm DL. We had no problems at all using this setup and MaxIm DL gave us access to all of the camera's functions.

The CCD sensor in this camera is relatively small, with an 11mm diagonal; using a refractor with a focal length of 509mm yielded a field of view of 1º by 0.75º. However, what this chip lacks in size it more than makes up for in sensitivity. We were very impressed with its ability to collect photons without adding much in the way of unwanted thermal noise.

There are also some advantages to a smaller sensor like this, especially for those starting out in deep-sky imaging. Because the field of view is relatively small, only the central portion of the light cone is intercepted. This is the region with the fewest of optical distortions – things such as field curvature in refractors and coma in reflectors – so correction is often not required. The small size also means that 1.25-inch filters (rather than their pricier 2-inch counterparts) are perfectly suitable, and the lower cost of smaller sensors makes the transition to a full astro-CCD camera a little easier on the pocket too.

Filtering the Universe

Because of the timing of the review we carried out most of our imaging under moonlit skies, so it made sense to use narrowband filtering for our images. Our setup also included a manual five-position filter wheel, attached with a male to male T-adaptor and a 22mm T-extension tube to obtain the correct spacing of 55mm with our standard focal reducer, and a trio of filters – Ha, OIII and SII. Our ▸

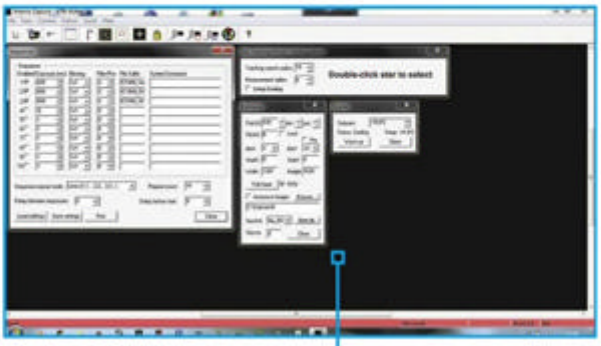
CHIP OFF THE OLD BLOCK

The Atik 414EX's Sony ICX825 EXview HAD II sensor has the same dimensions as the incredibly popular Sony ICX285 sensor, which has been used in numerous CCD cameras. However, the new chip is even more sensitive, making it a natural successor. The sensor is approximately 8.9x6.7mm, giving a diagonal measurement of 11mm. Each pixel is 6.45µm square, which is relatively large and adds to the high sensitivity of the sensor.

As a departure from normal practice, the sensor comes as a plastic package rather than the usual ceramic package used for most sensors of this type. However, any fears about this impacting on the effectiveness of the Peltier cooling were soon allayed, as our tests showed that it took just one minute and nine seconds to reach 20°C below the ambient temperature of 11.9°C. With regard to sensitivity whilst imaging, we were so impressed with the way the sensor performed, and its minimal thermal noise, that we didn't feel the need to take dark calibration frames.

DESICCANT PLUG

The sensor is mounted in a sealed chamber to keep moisture and dust at bay, and this is augmented by a desiccant insert that extracts any moisture from inside the chamber. Occasionally, this desiccant needs to be rejuvenated by heating it in an oven; the supplied tool makes it easy to remove the plug and access the dessicant to do this.



SOFTWARE

The excellent Artemis image capture software allows you to both control the camera and set up multiple imaging sequences. However, an ASCOM driver is also supplied, allowing control by third party software such as MaxIm DL and AstroArt. Atik's Dawn software is also included to calibrate, align and stack your images.

SET-POINT PELTIER COOLING

The Atik 414EX features set-point cooling down to 30°C below ambient, assisted by a cooling fan mounted on the rear of the casing with inlet ports towards the front. Cooling is vital for keeping the sensor's thermal noise under control during long exposures as this results in cleaner images.

SLIM CASING

The beautifully finished alloy casing is just 60mm in diameter, giving the camera a very small profile, and with a weight of only 381g it would be suitable for mounting on the front of a Fastar/ Hyperstar or Rowe-Ackermann telescope. Despite its diminutive size, the camera has a robust feel to it.

FIRST **light**

▸ target was a small section of the popular Soul Nebula, IC 1848, an emission nebula in the constellation of Cassiopeia. We generated a false-colour image of the nebula in the Hubble Palette by mapping SII to red, Ha to green and OIII to blue, producing a very satisfactory image.

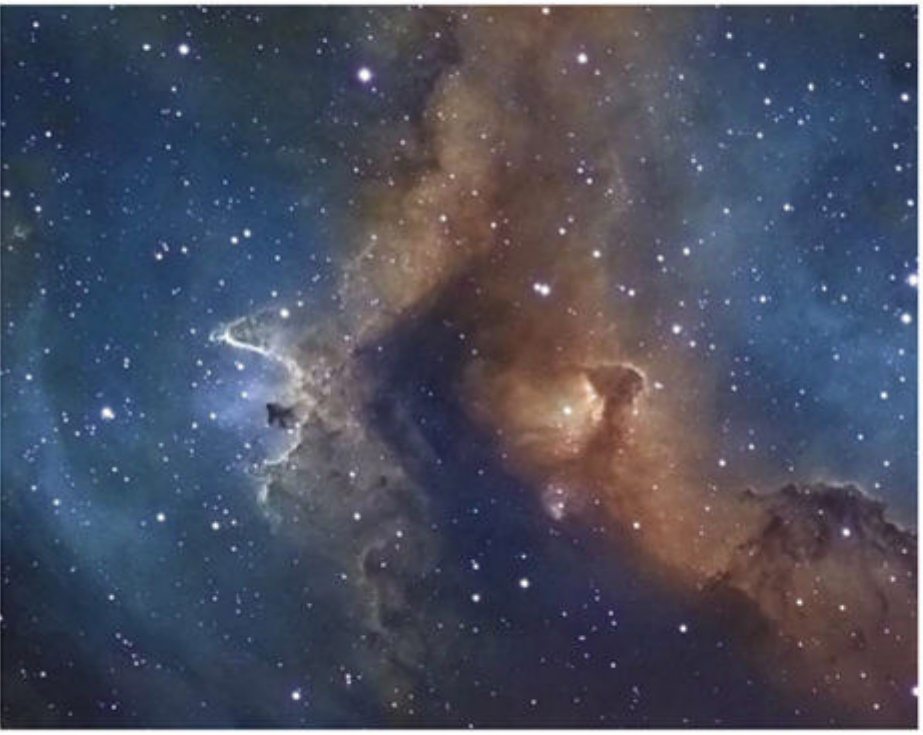
We also captured some test images of the quarter Moon to gauge how well the 'anti-bloom gate' worked at shorter exposures and were pleasantly surprised to find no streaks emanating from this bright source. An anti-bloom gate is a feature built into a CCD camera to stop vertical streaks from bright objects, caused when the 'well-depth' is exceeded and electric charge bleeds onto adjacent pixels. Although not designed for lunar imaging, we discovered that this camera can comfortably be pressed into service for this purpose.

Overall we were very impressed with the Atik 414EX camera as it worked straight out of the box, was quick to set up and begin imaging, and was very sensitive indeed. We would recommend this camera to deep-sky imagers making the transition from a DSLR to a fully fledged cooled CCD. S

VERDICT

BUILD & DESIGN	★★★★★
CONNECTIVITY	★★★★☆
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGING QUALITY	★★★★☆
OVERALL	★★★★★

▾ Part of the Soul Nebula; this shot is composed of 14 600-second exposures in Ha, OIII and SII



1.25-INCH AND T CONNECTIONS

The Atik 414EX is supplied with a 1.25-inch nosepiece that screws onto the front of the camera via a 42mm T-thread. This means that the camera can be attached directly to a standard eyepiece holder on your focuser or to a focal reducer, field flattener or coma corrector using an all-threaded connection for additional stability.

SKY SAYS...
Now add these:
1. Atik electronic filter wheel 2
2. Atik off-axis guider
3. Atik guide camera

WWW.THESECRETSTUDIO.NET, STEVE RICHARDS

Books

New astronomy and space titles reviewed

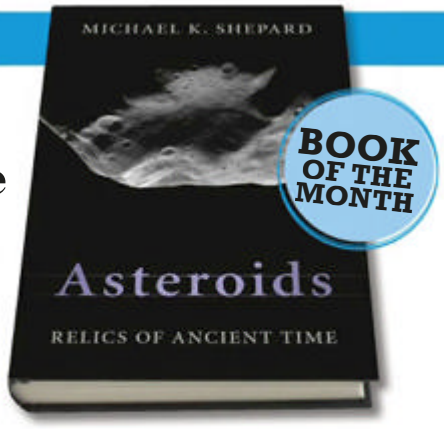
RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

You can order these books from our shop by calling 01803 865913

Asteroids
Relics of Ancient Time

Michael K Shepard
Cambridge University Press
£19.99 ● HB



Our Solar System is littered with debris left over from its formation, and tonnes of it rains down on Earth in the form of meteors and dust each day. Paradoxically, this cosmic rubble may be responsible for life flourishing on Earth as well as for catastrophic extinctions. Far from being a dull collection of rocks, asteroids and meteorites can help us to piece together the history of our planetary system and prepare for our civilisation's future.

Asteroids: Relics of Ancient Time provides a comprehensive and remarkably readable overview of asteroid and meteorite studies. An engaging combination of personal anecdote, historical discussion, and scientific explanation, it is both authoritative and accessible, and brings its subject to life uncommonly well.

Michael K Shepard, an astronomer specialising in radar studies of asteroids, covers the developments in his field from its advent in the late 18th Century through to the research of today and on to potential directions for future work. The story is developed through 10 chapters that focus on different aspects of asteroid and meteorite studies. Readers learn of the discovery of various types of asteroids, and of the historic and ongoing efforts to observe, classify and understand them using both ground-based methods and space-faring missions.

Like comets, asteroids may hold the secrets of the early Solar System

Equally in-depth attention is given to the interplanetary debris that falls to Earth, with comprehensive discussions of meteorites and meteor impacts including informative primers on the relevant geology and physics. Additional chapters focus on what all this interconnected study can tell us about the formation, evolution and future of our planetary system and our planet.

Foremost among the book's many strengths is its focus on human experience. With evocative descriptions of people combing exotic landscapes for meteorites and first-person reflections on his daily work, Shepard grabs readers' attention on a human level and doesn't let go. While the material is detailed and quite technical, the science is clearly explained and, time and again, reconnected to the big picture questions that motivate it, and which are relevant to us all.

★★★★★

OLIVIA JOHNSON *is an astronomer specialising in science education*

Reader price £17.99, subscriber price £16.99
P&P £1.99 Code: S0715/1 (until 24/08/15)

TWO MINUTES WITH MICHAEL K SHEPARD

What inspired you to write the book?
There are quite a few popular books and articles on the threat of asteroids – the disaster story. There are also one or two on the potential mining opportunities. But there is little popular literature on the role of asteroids and their meteorite progeny in deciphering our origins, or on their fascinating historical back story. I felt these stories were worth telling.

Why are asteroids so important to study?
Although scientists are often perceived to work on narrow and specific problems, it is all directed to answering a few ultimate questions: what is the rest of the Universe like, what are the rules of its operation, how and when did humans get here, and are we alone in this vast expanse? Because asteroids are remnants from our Solar System's beginning, they are especially important for helping us to address these latter questions.

What do we have to look forward to in terms of asteroid discoveries?
Dawn has reached Ceres, the largest asteroid. In December 2014, the Japanese launched Hayabusa 2 to visit and return a sample from the primitive near-Earth asteroid (162173) 1999 JU3. In 2016, NASA will launch OSIRIS-REX to visit and return a sample of asteroid 101955 Bennu. And ESA recently announced a plan to launch a mission to the binary asteroid 65803 Didymos to both study it and slam a projectile into its moon to experiment with diverting an asteroid threat.

MICHAEL K SHEPARD *is the professor and chair for the Department of Environmental, Geographical and Geological Siences at Bloomsburg*

ISTOCK

Expanding Universe

Photographs from the Hubble Space Telescope

Owen Edwards
Taschen
£44.99 ● HB

In the 25 years since its launch the Hubble Space Telescope has transformed our view of the Universe, delivering a wealth of scientific data from orbit alongside incredible images. Now German publisher Taschen, best known for luxurious art and photography books, has produced its own celebration – and it is a stunner.

For most of its 256 pages, the beautifully produced *Expanding Universe* leaves Hubble's photos to speak for themselves, reproduced on high-quality glossy pages. Gatefold spreads open to reveal many of the images at an even larger scale than that allowed by the book's own generous proportions. Captions are minimal, with essential info neatly catalogued in a visual index at the back, and a simple chapter structure takes us from the planets and other objects of the nearby Solar System, out to the edge of the visible Universe itself.

The images are bookended by a preface from current NASA administrator Charles Bolden, an essay by photography critic Owen Edwards that ponders both the science of these stunning images and their merits as works of art, and an interview between Edwards and Zoltan Levay, imaging group lead at the Space Telescope Science Institute. The text in the book is printed in English, German and French, which seems a little odd at first, though you soon get used to it.

There are definitely more informative books out there if you want to learn about the objects in these images, or the story of the telescope itself – but as a purely visual celebration of Hubble's 25 years in space, this one is hard to beat.

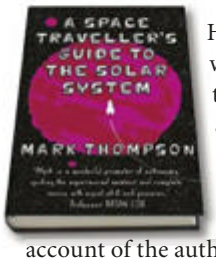
★★★★☆

GILES SPARROW *is a science writer and a fellow of the Royal Astronomical Society*

Reader price £39.99, subscriber price £38.99
P&P £1.99 Code: S0715/2 (until 24/08/15)

A Space Traveller's Guide to the Solar System

Mark Thompson
Bantam Press
£16.99 ● HB



Have you ever wondered what it would be like to travel through the Solar System? This book aims to fulfil the dreams of many a child – and adult. It starts with an account of the author's own dream, before shifting to the matter of navigation, propulsion and gravitational slingshots. Once prepared, the reader is launched into space aboard their trusty spacecraft.

After popping down to the Moon and swinging past the Sun, we sail out through the Solar System, visiting the various planets and smaller bodies in turn. There are a few interludes where the author imagines walking on the surface of the planet, exercising artistic licence in the form of a "reality suspension unit".

These excursions are fairly brief, however, and the majority of the book describes the properties of the planets and moons. The premise of being a space traveller helps with general narrative but isn't fully utilised, though if you can keep track there is certainly lots of information presented. On occasion, a few of the descriptions might be a little unclear, at least for a complete novice. Some, such as gravitational slingshots, would be helped with some simple diagrams, and it's a shame that the discussion of Earth's sidereal rotation is wrong.

The idea of studying the Solar System from an explorer's point of view is an intriguing one, but could have been used to greater effect and with more imagination. While full of information, and an interesting read, to achieve what it sets out to do the book could have been written fully from the point of view of the space traveller.

★★★☆☆

CHRIS NORTH *is a presenter on* The Sky at Night *and a Herschel Outreach Officer*

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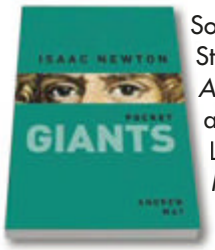
Isaac Newton; Pocket Giants

Andrew May
The History Press
£6.99 ● PB



Some 300 years before Stephen Hawking wrote *A Brief History of Time*, an earlier holder of the Lucasian Chair of Mathematics at the University of Cambridge published a book which, according to Andrew May, proved just as fashionable to own, if not necessarily to read or understand.

That book was *Philosophiae Naturalis Principia Mathematica*, the revolutionary scientific work of Isaac Newton, in which he codified his laws of motion. "Science has continued to advance since Newton's time," May points out, "but it has done so by building on his work, not by sweeping it aside."

As May explains in this concise and readable introduction to Newton, there's more to the man than the *Principia;* indeed, its shadow has encouraged too many historians to focus "on Newton's scientific achievements to the virtual exclusion of everything else". This includes Newton's exhaustive but largely unpublished alchemical and biblical researches. For May, this seriously misrepresents the man and how he saw the world: "The *Principia* could only have been written by someone who was at one and the same time a mathematician, a mystic, a truth seeker and a problem solver," he writes.

By focusing largely on Newton's work, May accepts that the man himself can appear somewhat one dimensional, but this remains an intriguing introduction to "the last of the magicians" who, before his death, had become a national – as well as scientific – institution.

★★★★☆

PAUL F COCKBURN *is a freelance science and technology journalist*

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Gear

Elizabeth Pearson rounds up the latest astronomical accessories

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020 3384 5187 • www.365astronomy.com

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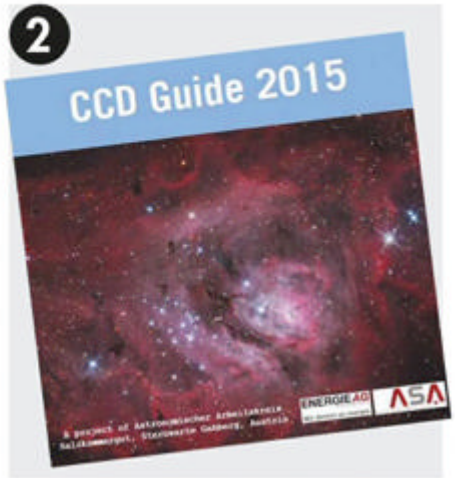

2 CCD Guide 2015

Price €29 • **Supplier** CCD Guide
www.ccdguide.com

This DVD guide helps you to plan out and get the most from your imaging sessions. It contains an archive of 4,500 images and an extensive catalogue of deep-sky objects.

3 Orion 1.25-inch Dark Frame Imaging Filter

Price £29 • **Supplier** SCS Astro
01823 665510 • www.scsastro.co.uk

Add this opaque filter to your setup to quickly capture dark frames. Can be used in 1.25-inch camera nosepieces, filter wheels and sliders.

4 Illuminated 12.5mm Plössl Eyepiece

Price £54 • **Supplier** Bristol Cameras
0117 914 0089 • www.bristolcameras.co.uk

A red LED illuminates a double crosshair in the reticule of this 1.25-inch eyepiece, designed to help with guiding and drift alignment.

5 Apollo Soyuz Tie

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6 Muonionalusta Meteorite Watch

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WHAT I REALLY WANT TO KNOW IS...
What next for the Hubble Space Telescope?

Tony Darnell looks at what the future holds for a space scope that has done more for astronomy than any other

INTERVIEWED BY PAUL SUTHERLAND

The Hubble Space Telescope is the most famous observatory ever built. It has been a powerful ambassador for astronomy. More than any other telescope, it has shown us our place in the Universe quite dramatically, with images that touch us at an emotional level.

I remember the first Hubble Deep Field image taken in 1995, pointed at a tiny, apparently empty patch of sky in Ursa Major, just 1/12th of the apparent width of the Moon. But a total exposure of 11 hours, built up over 10 days, showed us that patch was actually filled with nearly 3,000 galaxies. It was an image that profoundly affected me.

Hubble, with its 2.4m mirror, has not only photographed the distant Universe but also made amazing observations of the Solar System. For a long time it was basically the Mars weather channel, it was looking at the planet so much. And who can forget those incredible images of Comet Shoemaker-Levy 9 impacting on Jupiter in 1994?

But the space scope's story is also a very human one. Following its launch from the Space Shuttle Discovery in 1990, it was found to have faulty optics. It was out of focus and suffered spherical aberration. It became a laughing stock. Every late-night comedian had a joke about it and NASA was mortified.

Hubble has survived so long because it has regularly been repaired and upgraded, but without servicing its decline is assured

Back to the opticians

That was a really terrible time because NASA had spent a huge sum, equivalent to what we are spending today on the James Webb Space Telescope (JWST), in building it. But then Hubble got fixed in a Space Shuttle mission and that was dramatic. Corrective optics fitted in 1993 acted like spectacles, giving Hubble perfect sight.

Hubble has now been up there for 25 years, supported by servicing missions. But nothing lasts forever, and without a Space Shuttle to service it again, Hubble will eventually fall into disrepair.

Right now we are making plans to operate Hubble up until 2020. We'd like some overlap with its successor, the JWST, which is due to launch in 2018. And after 2020, if Hubble is still working, then I can't imagine people pulling the plug and not wanting still to use it, though that is my opinion, rather than NASA policy.

Five of Hubble's six gyroscopes, which keep it oriented, are still working, and it only needs two. Its instruments are mostly still functioning, including the Wide Field Camera 3, which is working beautifully. The real limiting factor is going to be the solar panels. They tend to degrade quickly. The other thing that will limit Hubble is its orbit, which will gradually decay until it falls back through the atmosphere, unless something is done to prevent that. This decay could happen as early as the late 2020s, or it may not until well into the 2030s.

So what are the options for the future? On the final servicing mission, a grappling ring was fitted to the back of the telescope. That would make it easy for a spacecraft to grab it and fly it into a much higher orbit for possible retrieval in the future. But no spacecraft currently exists that could bring Hubble home. As we get closer to the end, there is likely to be an outcry to save Hubble, just as there was when NASA tried to cancel the last servicing mission. But NASA are caught in a really difficult position because they are being asked to do amazing things with limited budgets.

Sentimentality may be too expensive for NASA when it is trying to fund new missions. We'd love to save Hubble, but it might just not be practical. But the JWST will be there and will take Hubble's place in spectacular fashion. We will see the very first stars ever created in the Universe and directly image planets around other stars. That will be amazing and will make up for the loss of Hubble.

ABOUT TONY DARNELL
Tony Darnell is an astronomy software technologist and social media manager at the Space Telescope Science Institute in Baltimore, which operates the Hubble Space Telescope.

The Southern Hemisphere in July

With Glenn Dawes

WHEN TO USE THIS CHART

1 JUL AT 00:00 UT
15 JUL AT 23:00 UT
31 JUL AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

JULY HIGHLIGHTS

On 1 July the early evening northwest sky holds a spectacular meeting of Venus and Jupiter, closer together than the apparent width of the full Moon. Jupiter then drops below the more brilliant Venus, the pair remaining within 6° for the month. For two days the thin crescent Moon joins this gathering: on the 18th it is to the lower left of Jupiter, and on the following night it forms an impressive triangle with Venus and mag. +1.4 Regulus (Alpha (α) Leonis). Jupiter sits below on this date.

STARS AND CONSTELLATIONS

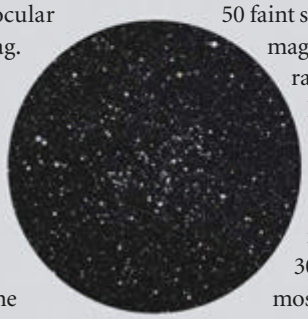
Sandwiched between Centaurus and Triangulum Australe is the constellation of the Compass, Circinus. It only has one distinctive star, mag. +3.2 Alpha (α) Circini. This forms the top of the instrument, the spikes marked by the 4th-magnitude stars Gamma (γ) and Beta (β) Circini, 7° northeast. The compass points towards another indistinct constellation, Norma, the Carpenter's Square. As both sit within the band of the Milky Way on the sky, they are home to a number of notable star clusters.

THE PLANETS

The early evening is dominated by Jupiter and Venus. Both slowly drop towards the Sun, setting around the end of twilight by month end. Saturn is due north in the early evening and can be observed through to the morning. Going into the outer Solar System, Neptune will be high enough to view in the late evening, while Uranus rises around midnight mid month and is a morning planet. Mercury is low in the dawn glow for the first week of July, but soon disappears into the solar glare.

DEEP-SKY OBJECTS

Between Alpha and Gamma Circini you'll find a great binocular double star consisting of mag. +5.0 Delta (δ) Circini (RA 15h 16.9m, dec. –60° 57') and mag. +5.7 HR 5661 separated by 4 arcminutes.



Near the northern boundary of Circinus are two open clusters, and the contrast between them is quite attractive. Mag. +7.9 NGC 5823 (RA 15h 5.5m, dec. –55° 36') in Circinus has about 50 faint stars of 11th- and 12th-magnitude, arranged in a raindrop (9x6 arcminutes). Its northern pointy end directs you towards NGC 5822 (pictured), 1° away in Lupus. This round, mag. +6.5 cluster, spanning 30 arcminutes, consists of mostly 9th-magnitude stars arranged in impressive curved lines in a magnificent star field.

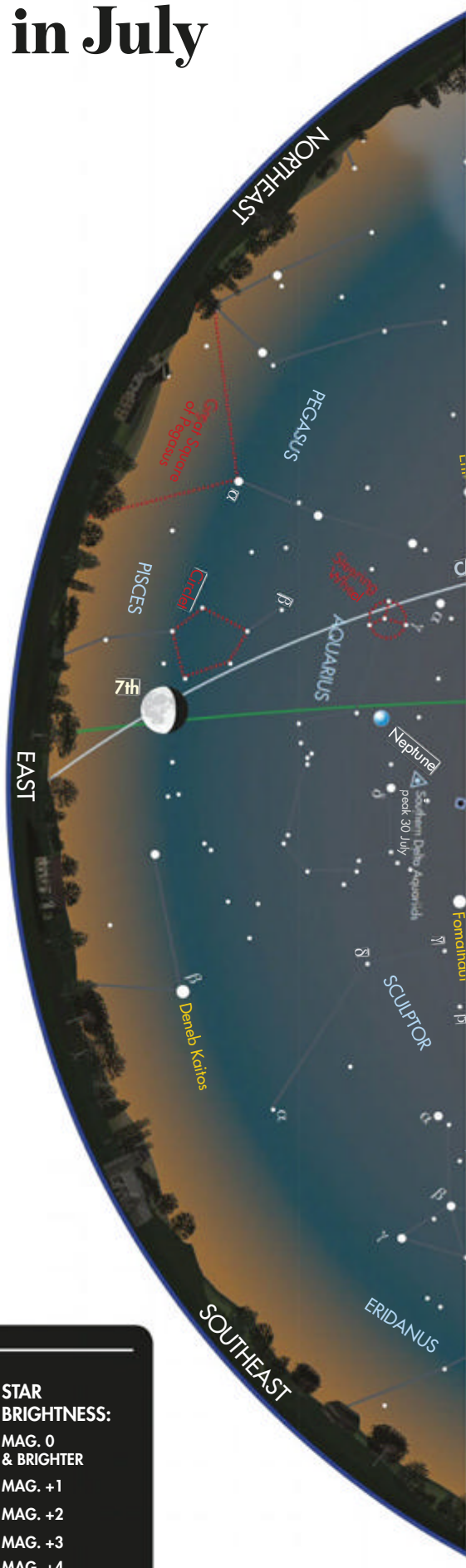


CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

ROBERTO MURA


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
DRACO
HERCULES
M92
CYGNUS
LYRA
Deneb
Vega
Summer Triangle
Northern Cross
M29
M57
Albireo
Veil Nebula
NGC 7000
M13
CORONA BOREALIS
BOÖTES
Arcturus
Alkaid
VULPECULA
M27
M71
Collinder 399
DELPHINUS
SAGITTA
Altair
AQUILA
Rasalhague
Rasalgethi
IC 4665
SERPENS CAUDA
SERPENS CAPUT
OPHIUCHUS
EQUULEUS
M15
Celestial Equator
M14
M12
M10
M5
SCUTUM
M11
M2
NGC 7009
Alpha Capricornid peak 30 July
4th
31st
1st
M17
M9
28th
Pluto
M107
Saturn
25th
M75
M22
M8
M19
M62
M6
M7
Teapot
M55
Antares
VIRGO
LIBRA
Ecliptic
22nd
Spica
CAPRICORNUS
M30
MICROSCOPIUM
SAGITTARIUS
SCORPIUS
Piscis Austrinids peak 28 July
PISCIS AUSTRINUS
GRUS
INDUS
CORONA AUSTRALIS
NORMA
LUPUS
ARA
CORVUS
PAVO
TRIANGULUM AUSTRALE
NGC 5822
NGC 5823
Rigel Kentaurus
ω Cen
CENTAURUS
HYDRA
M68
TUCANA
CIRCINUS
PHOENIX
OCTANS
APUS
NGC 4755
Jewel Box
Coalsack
47 Tuc
SMC
MUSCA
CRUX
IC 2944
Collinder 240
Achernar
HYDRUS
CHAMAELEON
South Celestial Pole
Southern Pleiades
NGC 3532
MENSA
CARINA
Eta Carinae Nebula
Miaplacidus
ANTLIA
RETICULUM
LMC
NGC 2070
VOLANS
VELA
Eclipse Cross
DORADO
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